



National Transportation Safety Board

Washington, D.C. 20594

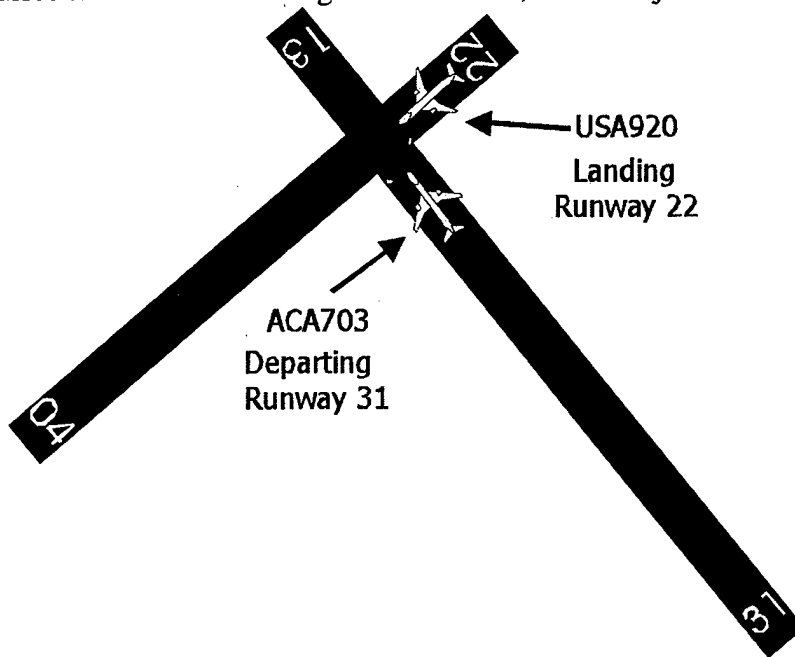
Safety Recommendation

Date: June 16, 2000

In reply refer to: A-00-32 through -40

Honorable Jane F. Garvey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On April 3, 1998, about 0821 eastern standard time, US Airways flight 920 (USA920), a McDonnell-Douglas DC-9, and Air Canada flight 703 (ACA703), an Airbus Industries A-319, nearly collided above the intersection of runways 22 and 31 at LaGuardia Airport (LGA), Flushing, New York (see figure 1). Both aircraft were scheduled passenger flights; USA920, as a domestic carrier, was operating under 14 Code of Federal Regulations (CFR) Part 121, and ACA703, as a foreign air carrier, was operating under 14 CFR Part 129 while in U.S. airspace. The incident occurred in visual meteorological conditions, and no injuries were reported.



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Figure 1. Approximate aircraft orientation for April 3, 1998, near midair collision (NMAC) at LGA

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At the time of the incident, aircraft landing at LGA were using runway 22 and departing aircraft were using runway 31. Runway 22 intersects runway 31 approximately 5,300 feet from the threshold of runway 31. According to the LGA tower local controller, USA920 was executing a visual approach to runway 22 and had been cleared to land. The local controller then cleared ACA703 for takeoff from runway 31. Approximately 30 seconds later, he reassessed the traffic situation and decided that ACA703 would not clear the intersection before USA920 crossed the threshold of runway 22.¹ The local controller then instructed USA920 to go around.² ACA703 was airborne and climbing before it reached the intersection with runway 22; consequently, USA920 and ACA703 were in the air when their paths crossed. The captain of USA920 saw ACA703 on his left and alerted the first officer, who was flying the airplane. The first officer immediately took evasive action to avoid a collision. Radar data were not available because both airplanes were below radar coverage at the time of the incident; however, in the NMAC report he filed with the FAA, the captain of USA920 estimated that his aircraft passed 85 feet below ACA703 with horizontal separation of 75 feet. The local controller estimated the separation distance at 20 feet.

On January 23, 1998, about 1819 eastern standard time, US Airways flight 1186 (USA1186), a Boeing 737, and American Airlines flight 350 (AAL350), a McDonnell-Douglas MD-80, nearly collided at the intersection of LGA runways 4 and 13 (see figure 2). The reported weather was ceiling 600 feet and visibility 2 miles. According to an NMAC report filed by the captain of USA1186, his aircraft was on a 2.5 mile final for an instrument landing system approach to runway 13 when the local controller cleared AAL350 for takeoff from runway 4. The USA1186 captain reported that AAL350 did not pass through the intersection of runways 4 and 13 until after USA1186 had crossed the runway 13 threshold. The runway 13 threshold is 1,700 feet from the intersection with runway 4 or 7.5 seconds flying time at an estimated approach speed of 135 knots.

¹ Federal Aviation Administration (FAA) Order 7110.65, "Air Traffic Control," section 3-10-4, "Intersecting Runway Separation" states in part, "Separate an arriving aircraft using one runway from another aircraft using an intersecting runway or a nonintersecting runway when the flight paths intersect by ensuring that the arriving aircraft does not cross the landing threshold or flight path of the other aircraft until one of the following conditions exists: ...The preceding aircraft has departed and passed the intersection/flight path or is airborne and turning to avert any conflict."

² The FAA Pilot/Controller Glossary defines a go-around as "instructions for a pilot to abandon his approach to landing. Additional instructions may follow. Unless otherwise advised by air traffic control [ATC], a visual flight rules aircraft or an aircraft conducting a visual approach should overfly the runway while climbing to traffic pattern altitude and enter the traffic pattern via the crosswind leg. A pilot on an instrument flight rules flight plan making an instrument approach should execute the published missed approach procedure or proceed as instructed by ATC."

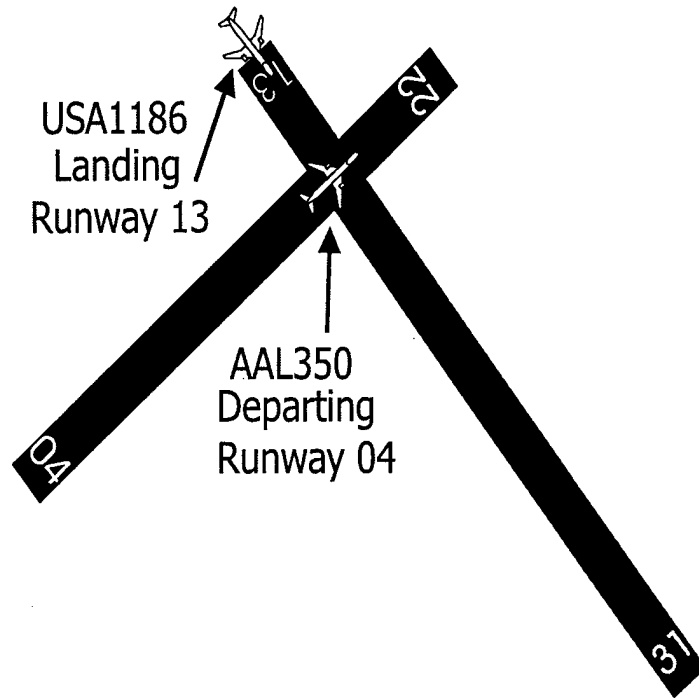


Figure 2. Approximate aircraft orientation for January 23, 1998, NMAC at LGA

The captain of AAL350 stated that he looked to his left as his aircraft passed through the runway 4/13 intersection and saw USA1186 approximately over the runway 13 threshold. Recorded air traffic control (ATC) communications indicate that after departure, one of the pilots of AAL350 said to the local controller, "that was close."

After USA1186 cleared the runway, the ground controller commented to the flight crew, "close call, huh?" One of the pilots replied in a laughing manner, "it sure was," then asked, "what's going on?" The ground controller replied, "I'm not sure, he [the local controller] just took the shot and, whew." The ground controller then said, "it was a slow roller, sir," (suggesting that the pilot of AAL350 was tardy in responding to the takeoff clearance). The USA1186 pilot then asked what kind of airplane AAL350 was; after being told it was an MD-80, he replied, "okay, thank you, that's what we thought." The ground controller then asked, "what color were his eyes?" The pilot replied, "it was pretty dark everywhere out there I couldn't quite see his eyes but saw everything else."

During the investigation of the April 1998 incident, the National Transportation Safety Board requested that LGA tower personnel provide it copies of all formal NMAC reports filed by pilots since the beginning of the calendar year along with voice recordings of the control positions involved in the incidents. Examination of this material revealed the January NMAC report. Quality assurance personnel at the Federal Aviation Administration's (FAA) eastern regional office had reviewed the pilot's report and associated controller statements but had not replayed the recorded ground control communications. The regional office investigators, therefore, were not aware of the content of the controllers' conversation with the crew of USA1186 and the seriousness of the incident.

The Safety Board's investigation of these incidents has identified several areas of concern that the FAA should address. Although the local controllers in both incidents were reportedly applying visual separation procedures, those procedures nonetheless resulted in unsafe situations. Both incidents were reported by the flight crews involved in them as NMACs, but LGA tower management did not report them as operational errors or as any other type of incident that would warrant internal notification to Air Traffic Service management.

Air Traffic Control Operational Procedures

Air traffic controllers are required to separate aircraft by using standards contained in the ATC handbook. The particular standard to be applied depends on the type of operation in progress. The local controller involved in the April 1998 incident stated that under the runway configuration in use at LGA at the time, the separation standard applicable to USA920 and ACA703 required that ACA703, departing from runway 31, pass through the runway 22/31 intersection before USA920 crossed the runway 22 threshold. When he decided that the required runway separation would not exist if he allowed USA920 to land, the local controller instructed its flight crew to go around. With both aircraft airborne, he was then required to provide visual separation between USA920 and ACA703; the runway-based separation standards no longer applied. However, there are no specific FAA standards for minimum horizontal and vertical separation distances applicable to tower use of visual separation between airborne aircraft. Further, the go-around instruction issued in the April NMAC incident to avoid violating runway separation requirements may have, in fact, increased the level of risk. Had the local controller involved in the January NMAC instructed USA1186 to go around, an incident very similar to the April NMAC might have occurred.

According to the LGA tower supervisor and the local controller involved in the April incident, LGA tower controllers are taught during on-the-job training that no aircraft should be cleared for takeoff from runway 31 once a turbojet arrival is within 2 miles of the runway 22 threshold. The supervisor characterized this practice as a "technique," rather than a procedure that is mandatory or documented in the facility's standard operating procedures. The local controller stated that USA920 was approximately 2 to 2.5 miles from the runway 22 threshold when he cleared ACA703 for departure; however, radar data indicate that USA920 was about 1.6 miles from the runway 22 threshold when the local controller issued the takeoff clearance to ACA703 and 2,000 feet from the runway 22 threshold at an altitude of 200 feet when the controller issued the go-around instruction.

By the time the Safety Board initiated the investigation of the April 1998 incident, radar data for the reported January 1998 NMAC between USA1186 and AAL350 were no longer available; therefore, investigators were unable to confirm USA1186's proximity to runway 13 when AAL350 was cleared for takeoff from runway 4. However, the circumstances of both incidents suggest that the spacing being used by LGA tower personnel between arriving and departing aircraft using intersecting runways may not provide an adequate margin for error in controller technique.

According to the FAA, in response to the April 1998 incident, all FAA terminal supervisors and controllers, including those at LGA, received additional training on intersecting runway operations and incident reporting requirements. However, the rules and procedures for application of visual separation remain unchanged, preserving the possibility that aircraft engaged in operations on intersecting runways may come within unsafe proximity. By the time a controller determines that two aircraft operating on intersecting runways will not meet runway separation requirements, it may be too late for an approaching aircraft to execute a go-around maneuver as a safe alternative to landing in violation of runway separation standards. A collision was averted in the April 1998 incident mainly because of last-second maneuvers by the crew of USA920.

Situations in which ATC and flight crews are essentially without safe alternatives cannot be permitted to occur; air traffic procedures must allow sufficient spacing to guarantee adequate separation between converging aircraft. It appears that the 2-mile converging operations spacing standard used at LGA may be inadequate to prevent incidents such as those described in this letter. Therefore, the Safety Board believes that the FAA should amend LGA tower procedures to extend the spacing standard used to separate converging arrivals and departures to a distance greater than 2 miles. Further, because an undocumented facility practice was inadequate to ensure proper separation during intersecting runway operations under visual flight conditions at LGA and because this situation may not be unique to LGA, the Safety Board believes that the FAA should review intersecting runway operations at all airports served by scheduled air carriers. The review should determine, for instrument and visual operations, if a formal restriction on clearing departing aircraft for takeoff when an arriving aircraft is a specified distance from the threshold would reliably provide safe separation between arriving and departing aircraft on intersecting runways.

FAA Order 7110.65 does not require terminal controllers to issue traffic advisories to pilots when applying visual separation between arriving or departing aircraft on intersecting runways. Accordingly, the local controllers in the January and April 1998 incidents did not provide advisories about traffic using the intersecting runway to any of the crews involved. If the controllers had done so, the crews may have been able to take more timely evasive action and may have done so with less risk. To improve pilots' awareness of other traffic, reduce the risk of startling crews during a critical phase of flight, and permit advance consideration of an alternate course of action should one become necessary, controllers should be required to advise pilots involved in intersecting runway operations of the location and direction of flight of any crossing traffic. Therefore, the Safety Board believes that the FAA should amend FAA Order 7110.65, "Air Traffic Control," to require that controllers provide traffic advisories to the flight crew of each aircraft operating on intersecting runways where flightpaths converge. Further, the Safety Board believes that the FAA should amend the Aeronautical Information Manual to inform pilots that controllers will issue traffic information about aircraft operating on intersecting runways where flightpaths converge and explain the rationale for the procedure.

Reporting and Investigation of ATC-Related Events

The local controller involved in the April 1998 incident told Safety Board investigators that he informed the tower supervisor about the NMAC, even though the supervisor was standing directly behind him monitoring the operation from the coordinator position.³ The supervisor told Safety Board investigators that he first saw USA920 near the departure end of runway 22, which was after the aircraft had crossed ACA703's path. Despite the controller's report, the supervisor decided not to conduct any further inquiry. This decision concerns the Safety Board because, even if the supervisor did not actually see the near-collision, other indicators should have alerted him that an unsafe incident had occurred. For example, he received calls expressing concern about the event from USA920's captain, the FAA's eastern regional office, and the chief pilot's office of US Airways. Even after this, he did not investigate further, and the incident was not reported to FAA management.

On the basis of other incidents that have occurred since the NMAC incidents at LGA, the Safety Board remains concerned about the adequacy of the FAA's processes for identifying and categorizing ATC errors. For example, on June 22, 1998, the captain of American Airlines flight 758 (AAL758), a Fokker F-100, filed a formal report with the ATC tower at Tulsa International Airport (TUL), Tulsa, Oklahoma, after experiencing what he believed to be an NMAC. The Safety Board learned that a Cessna 172 had been cleared for takeoff from runway 18R with ATC approval for an eastbound turn on course, crossing the extended centerline of runway 18L. AAL758 was then cleared for takeoff from runway 18L. According to the captain's report, he was retracting the landing gear when the local controller provided a traffic advisory on the Cessna. The captain sighted the Cessna about 500 feet above ground level, just as AAL758's Traffic Alert and Collision Avoidance System issued a resolution advisory alerting the crew to the potential collision threat. AAL758 turned right to avoid the Cessna and continued to climb.

In his NMAC report, the captain estimated that the aircraft were separated by 100 feet vertically and 200 feet laterally. Although this incident clearly compromised safety of flight and was directly related to unacceptable ATC performance, the FAA processed the incident as an NMAC rather than as an operational error⁴ because Tulsa tower personnel and the FAA's Air Traffic Division headquarters staff contend that separation standards were met. NMACs not associated with an operational error are investigated by FAA flight standards personnel, who primarily focus on pilot performance rather than possible ATC shortcomings. It appears from the two incidents at LGA and the one at TUL that there is no FAA requirement to investigate and

³ FAA Order 7210.3, "Facility Operation and Administration," section 5-2-7, states in part, "Any employee who is aware of an occurrence that they believe to be an operational error/deviation shall immediately report that occurrence to the supervisor/manager-in-charge, or in their absence, any available supervisor or controller-in-charge."

⁴ An operational error is an ATC action that results in loss of required separation between aircraft. An operational deviation occurs when a controller fails to comply with a rule, but the error does not result in a loss of separation between aircraft. Allowing an aircraft to enter restricted airspace without proper coordination is one example of an operational deviation. Either type of incident triggers an internal ATC investigation and may result in retraining or disciplinary action against the responsible controller. The LGA and TUL incidents do not technically qualify as operational errors or deviations because no separation standard or mandatory procedure was violated.

report on the ATC aspects of NMAC incidents that occur while controllers are applying visual separation.

Monitoring of the quality of air traffic services could be greatly enhanced by the establishment of a consistent process for handling incidents that may expose ATC performance deficiencies. Such incidents include operational error reports, pilot deviation reports, NMAC reports involving at least one aircraft in contact with ATC, complaints from pilots or passengers about ATC services, execution of evasive action maneuvers by aircraft under ATC control, issuance of emergency control instructions to resolve potentially hazardous situations, or other reports related to the safety of the ATC system received from internal or external sources. A central review function could be assigned responsibility for screening all such incidents to ensure that issues of concern are identified and addressed by the appropriate FAA organizations.

The FAA Office of Accident Investigation may be an appropriate location for this evaluation function because it is not part of the Air Traffic Service and can make independent decisions on the evaluation and classification of incidents. Therefore, the Safety Board believes that the FAA should formally evaluate all reported safety-related events for potential ATC performance deficiencies and assign responsibility for the classification of all such events that occur within the National Airspace System to an internal oversight function that is independent of the Air Traffic Service.

Near Midair Collision Reporting

FAA Order 8020.11, "Aircraft Accident and Incident Notification, Investigation, and Reporting," states that, "control personnel shall not ask flight crewmembers if they intend to file a[n NMAC] report." The Safety Board notes that controllers in contact with aircraft involved in NMAC incidents are often the first official recipients of information that a potentially hazardous situation has occurred; therefore, they are in a position to help ensure that an NMAC is reported and investigated. The Board is concerned that the FAA's policy may negatively affect the number of NMAC incidents that are reported. Therefore, the Safety Board believes that the FAA should amend FAA Order 7110.65, "Air Traffic Control," to require that controllers ask any member of a flight crew receiving ATC services who expresses concern about the proximity of another aircraft if he or she desires to file a formal NMAC report. Further, although the current reporting form does establish that one or both aircraft involved in an NMAC were in contact with ATC, it does not provide information on ATC's specific role and actions in the event, if any. To help identify incidents for which investigation into ATC performance or procedures may be needed, the Board believes that the FAA should modify FAA Form 8020-21, "Preliminary Near Midair Collision Report," to include a section describing ATC actions relevant to the incident.

Air Traffic Control Data Retention

FAA Orders 7210.3, "Facility Operation and Administration," and 8020.11, "Aircraft Accident and Incident Notification, Investigation, and Reporting," require that FAA radar data and recorded voice communications be retained for a period of 15 days before the recording media is returned to service. Although the current 15-day retention limit did not adversely affect

the Safety Board's investigation of the incidents at LGA and TUL, it has limited the information available for the investigation of other incidents. The Board is concerned that it may continue to do so in the future. Additionally, under International Civil Aviation Organization procedures, foreign air carriers and their respective governmental agencies have the right to request information for their investigations of incidents involving foreign aircraft that were operating under FAA control. Under current requirements, the 15-day retention period may expire by the time such a request reaches the Safety Board through investigative channels.

The Safety Board notes that currently available recording and storage technology should enable the FAA to lengthen the retention period for operational data beyond 15 days. For example, the FAA is now able to use digital voice recording systems and, in most facilities, personal computer software to quickly retrieve and review recorded radar data. This technology has also made it possible to remove from service older recording media, such as reel-to-reel recorders and large computer disk packs. Because of the compact size of modern storage media, additional space requirements would be minimal and should not impose an undue burden on facilities required to retain additional data.

The Safety Board considers an extended retention period of 45 days to be adequate to meet investigative needs for data. Therefore, the Safety Board believes that the FAA should amend FAA Orders 7210.3, "Facility Operation and Administration," and 8020.11, "Aircraft Accident and Incident Notification, Investigation, and Reporting," to require that ATC facilities retain recorded voice communications and radar data for 45 days.

Use of Unrecorded Telephone Lines in ATC Facilities

After landing, the captain of USA920 asked ATC to provide a telephone number for the LGA tower and was given a number for an unrecorded line.⁵ When he called the tower, the captain asked to speak with the tower supervisor to discuss the incident. According to the supervisor's description of the conversation, the captain asked what had happened and why his flight was instructed to execute a go-around. The supervisor said that he told the captain that ACA703 had been slow in departing. The captain then asked if ACA703's crew knew that USA920 was on final approach for runway 22. The supervisor replied that he could not answer the question.⁶ According to the supervisor, USA920's captain then asked him to tell the local controller that he had done a good job.

In a subsequent telephone interview with Safety Board investigators, the captain of USA920 refuted the supervisor's account of the conversation. According to the captain, the supervisor told him that the local controller was distracted by a spilled cup of coffee after clearing ACA703 for takeoff. When the local controller looked up, he decided that ACA703

⁵ FAA Handbook 7210.3, "Facility Operation and Administration," states, "Air traffic facilities shall record operational communications to the maximum extent practicable." Telephone calls on nonoperational lines normally are not recorded.

⁶ In a subsequent interview with Safety Board investigators, the supervisor denied witnessing the NMAC and stated that he had not discussed the incident with the controller before speaking with the captain; therefore, he was not aware of the details of the incident.

would not pass through the runway intersection before USA920 crossed the threshold of runway 22. The local controller then instructed USA920 to go around. According to the captain's account, the supervisor complimented him on the "outstanding job of missing ACA703" and on the "good job of getting back around to land." Because the conversation was not recorded, the discrepancies between the two accounts of the conversation could not be resolved conclusively.

After the initial investigation at LGA, the Safety Board informed the manager of the Air Traffic Services evaluation and investigations staff at FAA headquarters of the discrepancies between the LGA tower supervisor's account of the conversation and the account provided by the captain of USA920. The supervisor was subsequently relieved of his management duties for 10 days during an internal FAA investigation, which found that the incident had not been properly reported or investigated.

The Safety Board is concerned that valuable information about the April 1998 incident was lost because the conversation between the tower supervisor and the captain of USA920 was not recorded. Recording conversations of personnel from ATC facilities that pertain to an accident, incident, or ATC performance creates an official record that can be used in case the event is investigated. Therefore, the Safety Board believes that the FAA should amend FAA Order 7210.3, "Facility Operation and Administration," to require that all telephone conversations with personnel at ATC facilities relating to an aircraft accident, incident, or ATC performance shall be conducted on recorded telephone lines.

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

Amend LaGuardia tower procedures to extend the spacing standard used to separate converging arrivals and departures to a distance greater than 2 miles. (A-00-32)

Review intersecting runway operations at all airports served by scheduled air carriers. The review should determine, for instrument and visual operations, if a formal restriction on clearing departing aircraft for takeoff when an arriving aircraft is a specified distance from the threshold would reliably provide safe separation between arriving and departing aircraft on intersecting runways. (A-00-33)

Amend Federal Aviation Administration Order 7110.65, "Air Traffic Control," to require that controllers provide traffic advisories to the flight crew of each aircraft operating on intersecting runways where flightpaths converge. (A-00-34)

Amend the Aeronautical Information Manual to inform pilots that controllers will issue traffic information about aircraft operating on intersecting runways where flightpaths converge and explain the rationale for the procedure. (A-00-35)

Formally evaluate all reported safety-related events for potential air traffic control performance deficiencies and assign responsibility for the classification of all such events that occur within the National Airspace System to an internal oversight function that is independent of the Air Traffic Service. (A-00-36)

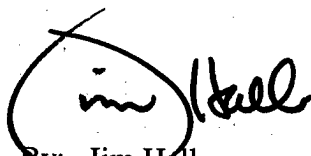
Amend Federal Aviation Administration Order 7110.65, "Air Traffic Control," (ATC) to require that controllers ask any member of a flight crew receiving ATC services who expresses concern about the proximity of another aircraft if he or she desires to file a formal near midair collision report. (A-00-37)

Modify Federal Aviation Administration Form 8020-21, "Preliminary Near Midair Collision Report," to include a section describing air traffic control actions relevant to the incident. (A-00-38)

Amend Federal Aviation Administration Orders 7210.3, "Facility Operation and Administration," and 8020.11, "Aircraft Accident and Incident Notification, Investigation, and Reporting," to require that air traffic control facilities retain recorded voice communications and radar data for 45 days. (A-00-39)

Amend Federal Aviation Administration Order 7210.3, "Facility Operation and Administration," to require that all telephone conversations with personnel at air traffic control (ATC) facilities relating to an aircraft accident, incident, or ATC performance shall be conducted on recorded telephone lines. (A-00-40)

Chairman HALL and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.


By: Jim Hall
Chairman



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: June 1, 2000

In reply refer to: A-00-41 through -45

Honorable Jane F. Garvey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On February 9, 1998, a Boeing 727, registration No. N845AA, operating as American Airlines flight 1340, crashed short of the runway while on a coupled instrument landing system (ILS) category II approach to runway 14R at Chicago O'Hare International Airport (ORD). The approach was normal until the airplane passed through 200 feet above ground level (agl), where the airplane started a pitch oscillation that grew in time. The airplane descended below the ILS glide slope, then climbed above it, and finally descended below it again, impacting the ground 300 feet short of the runway threshold. Upon impact, the airplane slid over the threshold and then off the right side of the runway, where it came to rest. The airplane was extensively damaged, and 22 passengers and 1 flight attendant sustained minor injuries.

Flight 1340 was a regularly scheduled passenger flight from Kansas City, Missouri, to Chicago, Illinois. At the time of the approach, the ceiling was overcast at 100 feet, with visibility at 1/2 mile in freezing fog; the temperature and dew point were 28° F. The runway visual range (RVR) on runway 14R was 1,400 feet, variable to 1,800 feet. The surface wind was about 4 knots from the south. The weather minimums for the ILS category II approach to O'Hare runway 14R are a decision height of 110 feet radio altitude and an RVR of 1,200 feet. Thus, the ceiling and visibility were close to the category II minimums at the time of the accident.

A primary concern during the Safety Board's continuing investigation of the accident has been to determine the reasons for the pitch oscillations during the approach. Investigators are considering several possibilities, including flight control inputs by the autopilot. Test results indicate the existence of an autopilot system anomaly that, under certain conditions, can produce undesirable pitch oscillations in the 727.

Airplane damage precluded functional checks of the autopilot equipment while it remained onboard the airplane, so Safety Board investigators removed the Sperry Aerospace SP-150¹ autopilot components and bench tested them at the Honeywell, Inc.,² facility in Seattle,

¹ Boeing 727s may also be equipped with an older model autopilot, the Sperry SP-50. Although the autopilot installed on the accident airplane was an SP-150, this letter also addresses issues regarding the SP-50 autopilot.

² Honeywell, Inc., purchased Sperry Aerospace in 1986.

Washington. In addition, investigators installed and ground tested the navigational and autopilot equipment from N845AA in another 727 at the American Airlines facility in Tulsa, Oklahoma. Although the bench and airplane tests were satisfactory, the investigators discovered that a 1983 service bulletin (SB) issued by Sperry, to change the sensitivity schedule of the autopilot while in approach mode, had not been completed on the autopilot system installed in the accident airplane. Investigators explored the consequences of not changing the sensitivity schedule in a study that was performed using the 727 engineering simulator at the Boeing Company in Renton, Washington. The purpose of the simulator study was twofold: (1) to determine the stabilizer and elevator movements required to reproduce the motions of the accident airplane; and (2) to evaluate the autopilot performance during a coupled ILS approach using different autopilot sensitivity schedules, in conditions similar to those of the accident flight.

The engineering simulator uses mathematical models of the airplane aerodynamics, mass properties, and propulsion and flight control systems, together with models of Earth's gravity and atmosphere, to compute the trajectory and orientation of the airplane and its response to engine and flight control inputs. The simulator also contains mathematical models of the airplane's autopilot systems, which duplicate actual autopilot commands. The simulation incorporates these commands into its flight control models to compute control surface deflections and the resulting airplane motion.

The investigators were able to estimate the stabilizer and elevator movements during the accident scenario using information from the 727 engineering simulator and trim-in-motion sounds from the accident airplane's cockpit voice recorder. In addition, the simulator study showed that the autopilot sensitivity schedule has a significant effect on the autopilot performance during a coupled ILS approach.

The ILS provides electronic signals to guide the pilot (and autopilot) in flying the airplane to the runway. The localizer course³ is usually aligned with the runway, and the localizer signal provides electronic angular horizontal displacement information to receivers on the airplane. Likewise, the glide slope is usually a 3° flight path to a point about 1,000 feet down the runway from the approach end. The glide slope signal provides electronic angular vertical displacement from the design flight path angle. The electronic signals are processed on the airplane; instruments indicate whether the airplane is on the localizer and glide slope, or indicate how much, and in which direction, the airplane has deviated from them. The information provided to the pilot via displays on the instrument panel, or directly to the autopilot, indicate whether the airplane should continue on course, or fly up, down, left, or right to get back on course.

Needle deflections on the instruments show how far the airplane has deviated from the localizer or glide slope. The amount of displacement is commonly expressed in "dots." For example, 1 dot of needle displacement indicates that the airplane is about 0.32° offset from the 3° glide slope. At the runway threshold, a 1-dot fly down position would indicate that the airplane was about 6 feet above the glide slope. At the outer marker, typically about 5 miles from the

³ The path over the ground to the approach end of the runway.

runway, a 1-dot fly down would indicate that the airplane is about 200 feet above the glide slope even though the angular displacement would be the same for both cases.

If the airplane was at the outer marker, the autopilot would have to provide a certain level of elevator input to move the airplane from a 1-dot fly down position to being "on" the glide slope. However, at the runway threshold, the autopilot would have to provide for much less elevator correction for the same 1-dot indication because the actual vertical distance to be corrected is much less.

Because glide slope deviations close to the runway require smaller pitch corrections than those required far from the runway, the autopilot sensitivity has to be reduced as the airplane nears the runway. This process is called autopilot desensitization. The appropriate sensitivity depends on distance from the runway, but if the ILS does not provide distance measuring equipment (DME) information, there is no way to directly measure this distance. Therefore, to properly set, or schedule, the sensitivity, the distance from the runway must be estimated based on other, measurable parameters. One method of estimating distance from the runway is to continually use radio altitude and the geometrical relationship between altitude and distance for a glide slope of about 3° . As the radio altitude decreases, the airplane is assumed to be closer to the runway, and the autopilot sensitivity is reduced appropriately. This method will be in error when the terrain preceding the threshold has significant peaks or valleys, or if the glide slope differs significantly from the 3° or other angle assumed by the method. However, the method is not affected by the ground speed of the airplane.

Another way to estimate the distance from the threshold is to measure the time elapsed since passing a point of known distance from the runway, and then to calculate the distance traveled from that point by multiplying the measured time by an assumed ground speed. This time-based method was used by the Sperry SP-150 autopilot installed on the accident airplane (N845AA). The SP-150 is capable of scheduling the sensitivity based on radio altitude; however, the system on N845AA was set up to start desensitizing over a period of 150 seconds after passing through a radio altitude of 1,500 feet. During the 150 seconds, the autopilot sensitivity (or gain) would be reduced from a value of 1.0 to a value of 0.22. Upon receiving the middle marker signal on the ILS approach, the gain would further reduce to a value of about 0.055 over 30 seconds. If the middle marker signal is received before the gain reaches a value of 0.22, the gain will start to decrease at twice the original rate until reaching 0.22, and then it will continue to decrease to 0.055 over 30 seconds.

A characteristic of the time-based method of desensitizing the autopilot is that the gain will be scheduled properly only if the distance from the runway at 1,500 foot radio altitude is consistent with a 3° glide slope, and if the actual ground speed is relatively close to the ground speed the autopilot designers assumed when selecting the time period required for desensitization. If the ground speed is higher than the ground speed assumed in the autopilot design, the airplane will approach the runway before the desensitization period expires and the sensitivity will be higher than that intended by the design. If the ground speed is lower than the design ground speed, the autopilot will be desensitized when the airplane is still far from the runway and the sensitivity will be lower than that intended by the design.

The 150-second desensitization period used by the Sperry SP-50 and SP-150 autopilots was optimized for the approach airspeeds corresponding to a 40° flap setting. However, in the early 1980s, operators started landing the 727 at 30° flap settings and correspondingly higher airspeeds in order to improve the maneuverability of the airplane during the approach. American Airlines flight 1340 had 30° flap settings when it crashed during its approach. In November 1982 and February 1983, Sperry issued two SBs that described autopilot modifications to account for these new, higher approach airspeeds. The first, SB 21-1132-121 (issued November 23, 1982), advised operators to modify the vertical path couplers in SP-50 autopilots; the second, SB 21-1132-122 (issued February 7, 1983), contained identical language to advise operators to modify the pitch control channels in SP-150 autopilots:

SP-150 gain programming as a function of time is too slow for the faster approach speeds used today. This modification produces a faster gain reduction for glide slope signals. Accomplishment of this modification is optional based on individual operator or industry experience.

The modifications described in the SBs reduce the time required for autopilot desensitization from 150 seconds to 105 seconds. Compliance with these SBs is optional, and SB 21-1132-122, which was applicable to N845AA, was not accomplished.

During the Safety Board investigation, an American Airlines captain described a pitch event experienced by another 727. In November 1997, that airplane was making a coupled ILS category II approach to runway 14R at Chicago O'Hare when, at about 250 feet, the crew felt a bump and the airplane pitched up in response to being slightly below the glide slope. The airplane climbed through the glide slope, and then pitched down severely to recapture the glide slope. The captain called for a go-around, and believing that there had been an infringement on the ILS critical area, came back for another approach. When the same bump was felt again, the captain executed an auto go-around and diverted to the alternate. This 727 also had a time-based autopilot with a 150-second desensitization period.

In the simulator study at Boeing, investigators compared the performance of autopilots with 150-second and 105-second desensitization periods by using the simulator to compute, for each system, autopilot commands and the resulting airplane response while on a coupled ILS approach at conditions similar to the 1998 accident flight. To exercise the autopilot and provide it with the task of returning to and maintaining the glide slope, investigators used a variety of methods to disturb the airplane from the glide slope centerline.⁴ The simulator results show that at the approach speeds of the accident flight, the autopilot with the 150-second desensitization period responds to the disturbances by commanding oscillatory pitch changes that grow in time and result in significant deviations from the desired flight path. The altitude response computed by the simulator in these cases is very similar to that recorded by the accident airplane's digital flight data recorder.

⁴ The methods included initially trimming to glide slope angles other than 3° or inducing turbulence or vertical wind gusts.

Although the Safety Board's investigation of the flight 1340 accident has not been completed, the 150-second desensitization schedule is considered a likely factor in the destabilized approach of the accident flight and in the reported pitch event that occurred in 1997. The Board is concerned that other 727s equipped with unmodified SP-50 and SP-150 autopilots could experience, in conditions similar to those of the accident flight, undesirable and potentially dangerous pitch changes during coupled ILS category II approaches. Therefore, the Safety Board believes that the Federal Aviation Administration (FAA) should require operators of Boeing 727 aircraft equipped with Sperry Aerospace SP-50 and SP-150 autopilots to perform the modifications described in SB 21-1132-121 (for the SP-50 autopilots) and SB 21-1132-122 (for the SP-150 autopilots) if these 727 aircraft are used for coupled ILS category II approaches at flap settings less than 40°.

Simulator tests show that at the approach speed used on the accident flight, the autopilot can also command divergent oscillatory pitch changes with the 105-second desensitization period, although these diverged slowly and were always substantially less in magnitude than those resulting from the 150-second period. The resulting altitude deviations with the 105-second period were also substantially less than those resulting from the 150-second period. Nonetheless, the oscillations generated with the 105-second period occurred at an altitude just above the ILS decision height (at about 200 feet agl), and could alarm or distract pilots and destabilize the approach if encountered on an actual flight.

The Safety Board's investigation indicates that under the conditions of the accident flight, the performance of the Sperry autopilot with a 105-second desensitization schedule on coupled ILS approaches is superior to that of the autopilot with a 150-second desensitization schedule. However, even the autopilot with the 105-second desensitization period may exhibit unsatisfactory performance if it is not operated within the limitations of its design. The performance of the autopilot was not tested at approach speeds lower or higher than those of the accident flight; however, the characteristics of the time-based desensitization design and the simulator results suggest that if the approach speed were to increase, the 105-second period autopilot could be too sensitive near the runway, possibly resulting in the pitch oscillations and altitude deviations seen with the 150-second period autopilot at the original approach speed. At approach airspeeds less than that used on the accident flight (such as would be used at a full 40° flap deflection), the performance of the 150-second period autopilot could be superior to that of the 105-second period autopilot. These characteristics indicate that the appropriate desensitization period for the autopilot depends on the approach airspeed, which in turn depends on the flap setting used for the approach, among other factors (such as airplane gross weight and reported wind conditions).

The certification basis of the 727 equipped with Sperry autopilots is contained in Part 4b of the Civil Air Regulations (CAR), which date from 1953. Amendment 6 to Part 4b states in paragraph 4b.612(d) that

The automatic pilot system shall be of such design and so adjusted that, within the range of adjustment available to the human pilot, it cannot produce hazardous loads on the airplane or create hazardous deviations in the flight path under any conditions of flight appropriate to its use either during normal operation or in the event of malfunctioning, assuming that corrective action is initiated within a reasonable period of time.

The divergent pitch oscillations near the ground that can result from Sperry 150 autopilot commands under conditions similar to the accident flight constitute hazardous deviations in the flight path. The Safety Board believes that the autopilot performance in such circumstances does not conform to the requirements of paragraph 4b.612(d). Further, the FAA-approved airplane flight manual for the 727 does not define operating limitations on coupled approaches with Sperry autopilots that would restrict their use to conditions for which the autopilots were designed and under which their performance is confirmed to be satisfactory and safe. Therefore, the Safety Board believes that FAA should develop sets of operating limitations for Sperry Aerospace SP-50 and SP-150 autopilots on coupled ILS approaches that are appropriate for the desensitization schedule used by these autopilots so that every possible desensitization schedule has a corresponding set of operating limitations. The limitations should address approach flap settings and airspeeds specifically, and should also consider tolerances on winds, capture altitudes, glide slope angles, and/or other parameters that could adversely affect autopilot performance and safety of flight. The Safety Board also believes that the FAA should advise all operators of Boeing 727 aircraft equipped with Sperry Aerospace SP-50 and SP-150 autopilots to inform their pilots, maintenance, and engineering personnel of the dangers of conducting coupled ILS approaches at airspeeds that are not consistent with the desensitization schedule of the autopilots, and notify the operators that the FAA has been asked to develop operating limitations for the use of these autopilots on coupled approaches that will ensure that the approaches are conducted in a manner consistent with the autopilot design.

The Safety Board is further concerned that all autopilots currently utilizing time-based desensitization schedules on coupled ILS approaches may exhibit unsatisfactory performance when used with slower or faster approach speeds or other factors that were not envisioned during the original certification process. Therefore, the Safety Board believes that the FAA should review the certification of all autopilot systems that use time-based desensitization schedules and develop operating limitations, as necessary, for the use of these autopilots on coupled ILS approaches. The limitations should address approach flap settings and airspeeds specifically, and should also consider tolerances on winds, capture altitudes, glide slope angles, and/or other parameters that could adversely affect autopilot performance and safety of flight. The Safety Board further believes that the FAA should advise all operators of aircraft equipped with autopilot systems that use time-based desensitization schedules to inform their pilots, maintenance, and engineering personnel of the dangers of conducting coupled ILS approaches at airspeeds that are not consistent with the autopilot desensitization schedule, and notify the operators that the FAA has been asked to develop operating limitations for the use of these autopilots on coupled approaches that will ensure that the approaches are conducted in a manner consistent with the design of the autopilot.

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

Require operators of Boeing 727 aircraft equipped with Sperry Aerospace SP-50 and SP-150 autopilots to perform the modifications described in Sperry Service Bulletin (SB) 21-1132-121 (for SP-50 autopilots) and SB 21-1132-122 (for SP-150 autopilots) if these 727 aircraft are used for coupled instrument landing system category II approaches at flap settings less than 40°. (A-00-41)

Develop sets of operating limitations for Sperry Aerospace SP-50 and SP-150 autopilots on coupled instrument landing system approaches that are appropriate for the desensitization schedules used by these autopilots so that every possible desensitization schedule has a corresponding set of operating limitations. The limitations should address approach flap settings and airspeeds specifically, and should also consider tolerances on winds, capture altitudes, glide slope angles, and/or other parameters that could adversely affect autopilot performance and safety of flight. (A-00-42)

Advise all operators of Boeing 727 aircraft equipped with Sperry Aerospace SP-50 and SP-150 autopilots to inform their pilots, maintenance, and engineering personnel of the dangers of conducting coupled instrument landing system approaches at airspeeds that are not consistent with the desensitization schedule of the autopilots, and notify the operators that the Federal Aviation Administration has been asked to develop operating limitations for the use of these autopilots on coupled approaches that will ensure that the approaches are conducted in a manner consistent with the autopilot design. (A-00-43)

Review the certification of all autopilot systems that use time-based desensitization schedules and develop operating limitations, as necessary, for the use of these autopilots on coupled instrument landing system approaches. The limitations should address approach flap settings and airspeeds specifically, and should also consider tolerances on winds, capture altitudes, glide slope angles, and/or other parameters that could adversely affect autopilot performance and safety of flight. (A-00-44)

Advise all operators of aircraft equipped with autopilot systems that use time-based desensitization schedules to inform their pilots, maintenance, and engineering personnel of the dangers of conducting coupled instrument landing approaches at airspeeds that are not consistent with the autopilot desensitization schedule, and notify the operators that the Federal Aviation Administration has been asked to develop operating limitations for the use of these autopilots on coupled approaches that will ensure that the approaches are conducted in a manner consistent with the design of the autopilot. (A-00-45)

Chairman HALL and Members HAMMERSCHMIDT, GOGLIA and BLACK concurred in these recommendations.

By: 
Jim Hall
Chairman



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: June 1, 2000

In reply refer to: A-00-46 through -50

Honorable Jane F. Garvey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On April 15, 1997, at 1737 eastern daylight time, a Eurocopter¹ MBB-BK117-B-2 (BK117) helicopter, N909CP, operated by the Colgate-Palmolive Company, experienced a loss of control and crashed into the East River during takeoff from the 60th Street Heliport in New York, New York.² One passenger was killed, and the helicopter was destroyed. The pilot and a second passenger received serious injuries, and the copilot received minor injuries. Visual meteorological conditions prevailed for the corporate flight, destined for White Plains, New York. The flight was operated on a visual flight rules flight plan and was conducted under 14 Code of Federal Regulations (CFR) Part 91.

During takeoff, the helicopter climbed to approximately 30 feet and produced a loud bang. The helicopter rotated nose right, descended, struck the edge of the heliport pier, and crashed into the adjacent East River. Both pilots evacuated the aircraft underwater; however, the two passengers were found free of their restraints and unconscious in the cabin when rescued by divers.

Fatigue Cracking in the BK117 Vertical Fin

The accident investigation revealed that the upper half of the helicopter's vertical fin had completely separated from the remainder of the vertical fin. The separated sections, including the tail rotor gearbox and portions of the tail rotor blades, were found approximately 50 feet from the point of initial impact of the helicopter with the pier.

¹ Eurocopter Deutschland GmbH (formerly Messerschmitt, Bölkow - Blohm [MBB]).

² For more information, see NTSB Brief of Accident NYC97FA076 (enclosed).

Metallurgical examination of the wreckage established that the separation was caused by fatigue cracking in multiple components of the vertical fin structure, including the skin and spar. Fatigue cracking was discovered at five locations in the vertical fin skin beneath the lower edge of the left-hand yaw stability augmentation system (SAS) servo mount support.³ Fatigue cracks were also discovered in the vertical fin spar, which in effect partially severed the spar immediately adjacent to the noted skin cracks. The fatigue cracking in the skin originated at rivet holes common to the yaw SAS servo mount support and grew undetected to a length of approximately 5 1/2 inches before the ultimate separation of the vertical fin. The fatigue crack propagation in the skin was concealed by the installation of the yaw SAS servo mount support (see figures 1 and 2).

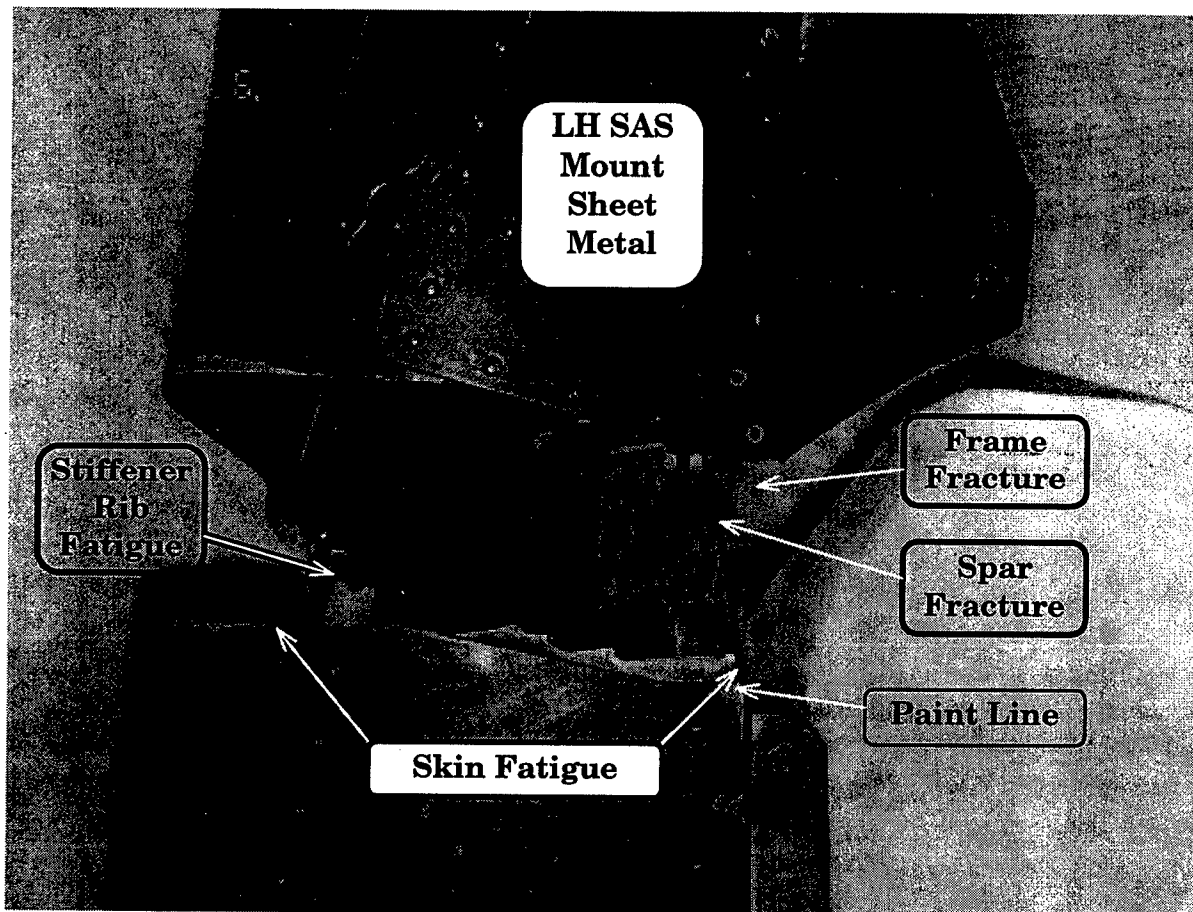


Figure 1. A left-side view of the fatigue area with the individual component fractures denoted. "Paint Line" arrow denotes the original position of the lower edge of the left-hand sheet.

³ This structure is composed of .040-inch thick, 11- by 14-inch aluminum sheet metal plates that are fastened to both sides of the vertical fin skin midway between the intermediate gearbox and the tail rotor gearbox.

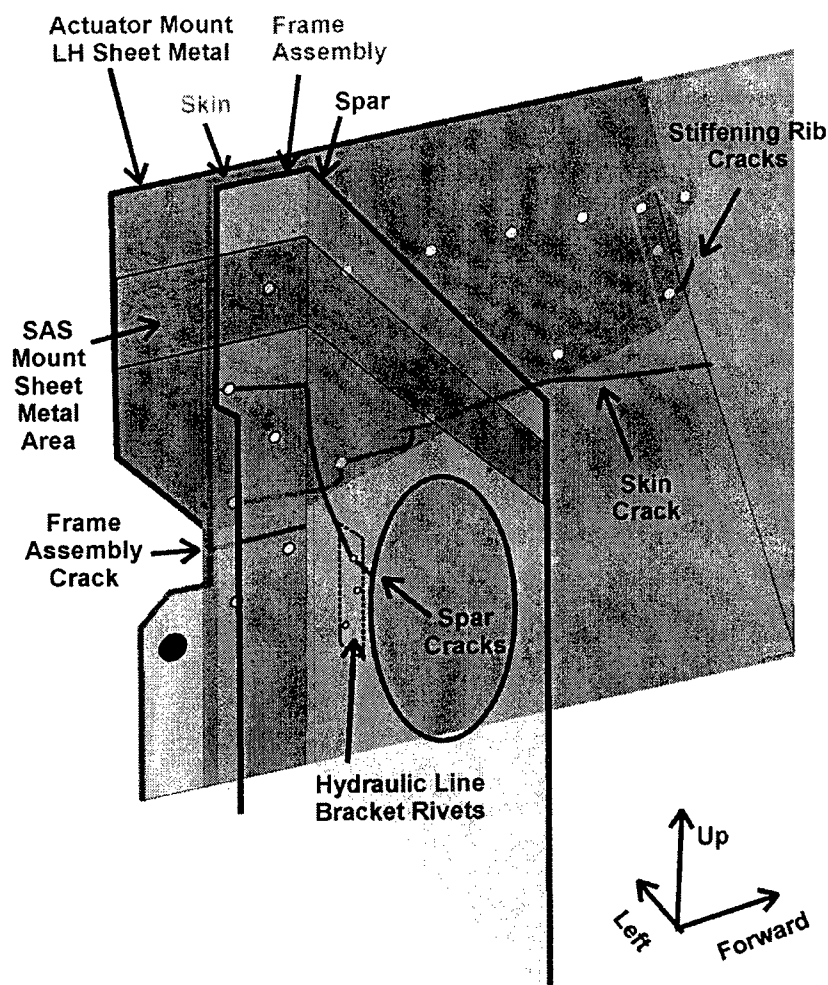


Figure 2. An illustration of the fin components in the area of the preexisting cracks. Of particular interest are the relative positions of the cracks in each member. Overlapping members are shown partially transparent to expose hidden detail. (Not to scale.)

Following this accident, Eurocopter released Alert Service Bulletin (ASB)-MBB-BK117-30-106, and the FAA issued priority letter Airworthiness Directive (AD) 97-09-16 (effective April 25, 1997) requiring immediate and repetitive visual inspections of both surfaces of the vertical fin spar on all BK117s for cracks, loose rivets, and other anomalies. The AD also instructed operators to visually inspect the skin and the left- and right-hand frames for cracks, loose rivets, or other anomalies. Revision 3 of the ASB, dated May 5, 1997, provided repair procedures applicable only for cracks found in the vertical fin spar and the left- and right-hand frames. Revision 3 of the ASB also instructed operators to modify the BK117 by reinforcing the vertical fin spar, frames, and adjacent skin within 600 flight hours and provided additional repetitive inspection criteria for the vertical fin structure.

The FAA issued AD 97-20-16 (effective October 24, 1997), which superseded AD 97-09-16, to mandate the structural repairs, modifications, and repetitive inspection

requirements recommended in ASB-MBB-BK117-30-106, Revision 3. Eurocopter then issued Revision 4 to the ASB on December 19, 1997, deleting a reference that previously allowed the use of blind rivets during the repair/modification of the vertical fin spar. With the issuance of AD 98-24-13 (effective December 4, 1998), which superseded AD 97-20-16, the FAA changed its reference from Revision 3 to Revision 4 of the ASB, thereby prohibiting the use of blind rivets during the repair/modification of the vertical fin spar.

Inspections of BK117s resulting from the FAA (and foreign) ADs revealed that at least four other helicopters worldwide had developed fatigue cracks in the vertical fin spar. In addition, Eurocopter reports indicate that before the Colgate-Palmolive accident, seven helicopters had developed fatigue cracking at various cross-sections of the vertical fin spar. However, several of the fatigue cracks were found in areas not specifically addressed by the inspection requirements of AD 98-24-13. Therefore, the Safety Board remains concerned that there may be additional incidents of fatigue cracking of BK117 vertical fins. Further, on the basis of its design review of the BK117 vertical fin, the Safety Board is also concerned that normal visual inspection techniques, for example, via spar lightening holes, may not be adequate to detect cracking damage in the underlying areas of the spar or leading-edge skin. Therefore, the Safety Board believes that the FAA should perform a fatigue evaluation/damage tolerance analysis of the Eurocopter BK117 vertical fin structure to ensure that the inspection requirements of AD 98-24-13 are adequate to detect crack growth in the underlying areas of the modified spar and leading-edge skin and to verify that the BK117 vertical fin spar is not susceptible to fatigue failure beyond those areas specifically identified by AD 98-24-13. If the susceptibility is not so limited or the inspection requirements are not adequate, the AD should be superseded to ensure that all fatigue cracks will be detected.

Manufacturer and Federal Aviation Administration Instructions on Rivet Use

An examination of the accident helicopter's maintenance history revealed that Colgate-Palmolive maintenance personnel had replaced the left-hand yaw SAS servo mount support in December 1992 because it was cracked. The BK117 design drawings specify that LN9198 solid rivets⁴ must be used when installing the mount support to the vertical fin skin; however, CherryMax blind rivets,⁵ part number CR3243-4, had been installed instead.⁶ The Safety Board's investigation determined that the BK117 maintenance manual does not contain any repair instructions regarding the substitution of blind for solid rivets. Instead, it refers the operator to

⁴ Solid rivets are one-piece rivets on which the shank is upset, that is, formed, into a head used to join sheet metal components. This is usually accomplished by placing a heavy steel "bucking bar" against the rivet shank while impacting the manufactured head to "buck" the rivet. Both sides of the joint must be accessible to install solid rivets.

⁵ Although many variations of blind rivets exist, nearly all blind rivets rely upon the principle of drawing a stem through a sleeve to accomplish the forming of a bucked head. Blind rivets are typically used to connect sheet metal structure where only one side of the structure is accessible or where limited space will not permit the use of a bucking bar.

⁶ The mechanic who replaced the yaw SAS servo mount support reported that he had used blind rivets instead of solid rivets because he believed there was a lack of working space within the vertical fin for bucking solid rivets.

FAA Advisory Circular (AC) 43.13-1A,⁷ "Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair," which indicates that blind rivets may be used in blind locations in accordance with certain conditions listed in Chapter 5 of the AC. Chapter 5 states in part:

...the mechanically locked stem NAS [National Airspace Standard] 1398, 1399, 1738, and 1739 rivets may be substituted for solid rivets in accordance with the blind rivet or aircraft manufacturer's recommendations. They should not be used where the looseness or failure of a few rivets will impair the airworthiness of the aircraft.

The Safety Board notes that although the CherryMax CR3243 blind rivet is generally accepted as a replacement for the NAS 1738B blind rivet, no FAA guidance confirms the interchangeability of these rivets. AC 43.13-1B, issued September 8, 1998, to supersede -1A, contains similar information regarding the use of blind rivets. However, neither version of the AC provides any information regarding the joint fatigue life of materials when joined with blind rivets. Postaccident testing conducted by Textron Aerospace Fasteners (TAF) and earlier testing conducted by Eurocopter consistently demonstrated that the joint fatigue life of materials fastened with blind rivets is less than the joint fatigue life of the same materials fastened with solid rivets.⁸ The Safety Board is concerned that other maintenance personnel may install blind rivets in applications where solid rivets are required, thereby reducing the structural fatigue life of an airframe. Therefore, the Safety Board believes that the FAA should issue a maintenance alert to all certificated airframe mechanics and inspectors to notify them of the circumstances of this accident and to inform them of the hazards associated with the installation of blind rivets.

The Safety Board notes that 14 CFR Part 43, Appendix A, Subpart (b), "Major Repairs," defines airframe repairs that are considered major and, therefore, requires that they be performed in accordance with technical data approved by the FAA. Although Appendix A states that repairs involving the substitution of material are considered major, it does not specifically address repairs involving the substitution of fastener types, such as rivets. Because the circumstances of this accident demonstrate that the substitution of fasteners can have a significant effect on airframe fatigue life, repairs involving such substitutions should be considered major. Therefore, the Safety Board believes that the FAA should revise 14 CFR Part 43, Appendix A to state that repairs involving the substitution of fastener types are considered major repairs. Further, because some manufacturers, such as Eurocopter, only refer operators to AC 43.13-1B without providing them with more detailed airframe structural repair instructions, such as those involving the substitution of fastener types, the Safety Board believes that the FAA should revise AC 43.13-1B to indicate that operators may substitute fastener types

⁷ This AC contains methods, techniques, and practices acceptable to the Administrator for the inspection and repair of civil aircraft when there are no manufacturer repair or maintenance instructions. According to the AC, it generally pertains to minor repairs; however, it may also be used as a basis for FAA approval of major repairs.

⁸ TAF Test Report No. C99-279, dated March 1, 1999. Eurocopter Hausmitteilung (Memo) D/EE56-55/97, dated July 22, 1997.

only when the application has been specifically authorized by the airframe manufacturer or a representative of the FAA.

Passenger Briefings

During the investigation, no passenger briefing cards were found onboard the helicopter. The chief pilot confirmed during an interview that briefing cards were not carried in the helicopter for the accident flight. Because the main cabin door on the left side of the helicopter was destroyed, it could not be determined if the passengers had attempted to open the door. There was no sign that any attempt had been made to open the emergency exit on the right side of the helicopter.

Interviews with the surviving passenger, who had been a passenger on several previous flights in the same helicopter, and with passengers on prior flights operated by Colgate-Palmolive disclosed that passenger briefings were not conducted on all flights. Many passengers revealed that they were unaware of the operational procedures for opening the main cabin door, the location and procedures for opening emergency exits, and the location and procedures for use of personal flotation equipment, although several remembered hearing passenger briefings in the past.⁹

The Safety Board notes that 14 CFR 91.107 requires that passengers be briefed on how to fasten and unfasten safety belts. Section 91.519 contains additional passenger briefing requirements for flights conducted under Part 91 but is applicable only to large and turbine-powered multiengine airplanes, not helicopters. Section 91.519 requires that passengers be briefed on the use of safety belts and shoulder harnesses; the location and means for opening passenger entry doors and emergency exits; location of survival equipment; ditching procedures and the use of flotation equipment; and the use of oxygen equipment installed on the airplane. Section 91.519 also provides that the oral briefing may be supplemented by passenger briefing cards if the pilot-in-command determines that the passengers are familiar with the contents of the briefing.

The Safety Board is concerned that there is no requirement for similar passenger briefings on large and turbine-powered multiengine helicopters; if the passengers on the accident flight had received such a briefing, both might have been able to escape and survive the accident. Therefore, the Safety Board believes that the FAA should require that passengers onboard large and turbine-powered multiengine helicopters receive passenger briefings similar to those required by 14 CFR 91.519 for passengers on large and turbine-powered multiengine airplanes.

⁹ Shortly after the accident, Colgate-Palmolive modified its passenger briefing standards and provided passenger briefings on emergency exits and flotation devices on all flights. The company has since shut down its flight operations department and no longer provides flight services.

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

Perform a fatigue evaluation/damage tolerance analysis of the Eurocopter BK117 vertical fin structure to ensure that the inspection requirements of Airworthiness Directive (AD) 98-24-13 are adequate to detect crack growth in the underlying areas of the modified spar and leading-edge skin and to verify that the BK117 vertical fin spar is not susceptible to fatigue failure beyond those areas specifically identified by AD 98-24-13. If the susceptibility is not so limited or the inspection requirements are not adequate, the AD should be superseded to ensure that all fatigue cracks will be detected. (A-00-46)

Issue a maintenance alert to all certificated airframe mechanics and inspectors to notify them of the circumstances of this accident and to inform them of the hazards associated with the installation of blind rivets. (A-00-47)


Revise 14 Code of Federal Regulations Part 43, Appendix A to state that repairs involving the substitution of fastener types are considered major repairs. (A-00-48)

Revise Advisory Circular 43.13-1B to indicate that operators may substitute fastener types only when the application has been specifically authorized by the airframe manufacturer or a representative of the Federal Aviation Administration. (A-00-49)

Require that passengers onboard large and turbine-powered multiengine helicopters receive passenger briefings similar to those required by 14 Code of Federal Regulations 91.519 for passengers on large and turbine-powered multiengine airplanes. (A-00-50)

Chairman HALL and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

By:



Jim Hall
Chairman

Enclosure

**National Transportation Safety Board
Washington, D.C. 20594**

Brief of Accident

Adopted 05/16/00

NYC97FA076	04/15/97	NEW YORK, NY	AIRCRAFT REG NO. N909CP	TIME (LOCAL) - 17:37 EDT
FILE NO. 1456				

MAKE/MODEL	-Eurocopter-MBB-BK117-B2	FATAL	SERIOUS	MINOR/NONE
ENGINE MAKE/MODEL	-Lycoming LTS101-750B-1	CREW	1	1
AIRCRAFT DAMAGE	-Destroyed	PASS	1	0
NUMBER OF ENGINES	-2			
OPERATING CERTIFICATES	-NONE			
TYPE OF FLIGHT OPERATION	-Executive/corporate			
REGULATION FLIGHT CONDUCTED UNDER	-14 CFR 91			

LAST DEPARTURE POINT DESTINATION	- Same as Accident - WHITE PLAINS, NY	CONDITION OF LIGHT	- Daylight
AIRPORT PROXIMITY	- On airport	WEATHER INFO SOURCE	- Weather observation facility
AIRPORT NAME	- 60TH STREET HELIPORT	BASIC WEATHER	- Visual (VMC)
RUNWAY IDENTIFICATION	- Unk/Nr	LOWEST CEILING	- None
RUNWAY LENGTH/WIDTH (Feet)	- Unk/Nr	VISIBILITY	- 10.000 SM
RUNWAY SURFACE	- Asphalt	WIND DIR/SPEED	- 200 /012 KTS
RUNWAY SURFACE CONDITION	- Dry	TEMPERATURE (F)	- 55
		OBSTR TO VISION	- None
		PRECIPITATION	- None

PILOT-IN-COMMAND	AGE	52	FLIGHT TIME (Hours)
CERTIFICATES/RATINGS			
Private, Airline transport			TOTAL ALL AIRCRAFT - 9400
Single-engine land			LAST 90 DAYS - 154
Helicopter			TOTAL MAKE/MODEL - 3900
INSTRUMENT RATINGS			TOTAL INSTRUMENT TIME - 584
Helicopter			

After taking off, the helicopter climbed to approximately 30 feet, and produced a loud bang. The helicopter rotated nose right several times, descended, struck the heliport pier and continued into the East River where it submerged. The pilots were evacuated underwater; the passengers were found in the cabin unconscious and recovered by divers. The throttles were found in the flight position. The investigation revealed that the upper 3 feet of the vertical fin had failed due to fatigue fractures and had separated, along with the tail rotor assembly. About 4 1/2 years prior, the left-hand yaw SAS actuator mounting plate attached to the vertical fin developed a crack and was replaced using blind rivets in lieu of the solid rivets specified in the manufacturer's design drawings. Neither the repair nor the substitution of rivets was addressed in the manufacturer's maintenance manual. Literature from the rivet manufacturer indicated that blind rivets may be substituted for solid rivets in most applications. No specific reference by the FAA was found to allow for this rivet substitution. The investigation revealed 11 other helicopters with fatigue cracking in the vertical fin spar similar to the accident helicopter. Testing revealed that materials fastened with blind

rivets are more susceptible to fatigue cracking than materials fastened with solid rivets. Passenger interviews disclosed that many were not aware of emergency exit locations, or how to operate them; life vests were available, but were not used.

Brief of Accident (Continued)

NYC97FA076
FILE NO.1456

04/15/97

NEW YORK, NY

AIRCRAFT REG NO. N909CP

TIME (LOCAL) - 17:37 EDT

Occurrence# 1 AIRFRAME/COMPONENT/SYSTEM FAILURE/MALFUNCTION
Phase of operation TAKEOFF - INITIAL CLIMB

Findings

1. NACELLE/PYLON, PLATE
2. MAINTENANCE, REPLACEMENT - COMPANY MAINTENANCE PERSONNEL
3. INFORMATION - INADEQUATE - MANUFACTURER
4. ACFT/EQUIP, INADEQUATE DESIGN - MANUFACTURER
5. MISC ROTORCRAFT, TAIL PYLON - FATIGUE
6. MISC ROTORCRAFT, TAIL PYLON - SEPARATION

Occurrence# 2 LOSS OF CONTROL - IN FLIGHT
Phase of operation TAKEOFF - INITIAL CLIMB

Occurrence# 3 IN FLIGHT COLLISION WITH TERRAIN/WATER
Phase of operation DESCENT - EMERGENCY

Findings

7. TERRAIN CONDITION - WATER
8. PASSENGER BRIEFING - INADEQUATE - PILOT IN COMMAND

The National Transportation Safety Board determines the probable cause(s) of this accident was:
Fatigue failure of the vertical fin, accelerated by the installation of blind rivets in lieu of solid rivets in the replacement of the yaw SAS mount support, which resulted in the loss of helicopter directional control and collision with the terrain (water). Factors contributing to the accident were: a lack of information regarding repair of the yaw SAS mount support in the manufacturer's maintenance manuals, and the design of the vertical fin which was susceptible to fatigue cracking. An additional factor was the lack of an adequate passenger briefing.



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: June 8, 2000

In reply refer to: A-00-51 through -53

Honorable Jane F. Garvey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On the morning of October 28, 1998, 2 gallons of a 35-percent hydrogen peroxide solution in water, an oxidizer¹ with corrosive properties, spilled in a cargo compartment of Northwest Airlines (Northwest) flight 957, a passenger-carrying airplane en route from Orlando, Florida, to Memphis, Tennessee. The solution leaked from two undeclared 1-gallon plastic bottles that had split. The bottles were in an ice chest that belonged to a passenger on the flight. The leaking hydrogen peroxide contaminated three mail sacks and an undetermined number of bags.

The leak was not discovered until cargo handlers in Memphis began to unload the baggage on flight 957. Thinking that the spilled liquid was water, the cargo handlers ignored it and transferred some of the baggage to other Northwest passenger-carrying flights, including flight 7, which then departed for Seattle, Washington. When flight 7 arrived in Seattle, two bags in a cargo compartment were smoldering, including one that had come from flight 957.

As a result of the spill, several people required treatment. In Memphis, 11 employees were treated at the airport's first aid station because their hands had been exposed to the hydrogen peroxide, and 2 more employees went to a local clinic, where they were treated and released. In Seattle, the employee who removed the smoldering bags from the cargo compartment was exposed to fumes. He went to a hospital for treatment and was released. None of the injuries were serious. Northwest estimated that the total cost of the damage to and the downtime on the aircraft and of the damage to the baggage was more than \$40,000.

The National Transportation Safety Board determines that the probable cause of the release of undeclared hazardous material aboard Northwest Airlines flight 957 was the passenger's failure to properly package and identify the hazardous material and inadequate inquiries from the Northwest Airlines agent about the contents of the cooler offered by the passenger. Contributing to the consequences of the incident were inadequate carrier procedures for handling a hazardous materials cargo spill.

¹ The Department of Transportation defines an oxidizer as "a material that may, generally by yielding oxygen, cause or enhance the combustion of other materials."

The passenger who had checked the ice chest at Orlando was a nurse. She had bought the hydrogen peroxide containers several years earlier and stored them unopened at an assisted care facility for the elderly in Fort Pierce, Florida, that she had once owned. Before her trip on flight 957, she had packed the two plastic bottles of hydrogen peroxide in a plastic ice chest with some sand and a bag of rolls.

She arrived at the airport at 0600 eastern standard time (EST); the flight was scheduled to depart at 0630 EST. She attempted to check seven items, including the ice chest, at Northwest's roadside skycap service. According to the skycap, he had been reluctant to check the bags because Northwest allows a passenger to have only two items checked without paying additional fees. He had told her that the fees must be paid at the ticket counter inside the terminal, but she explained that she was late and persuaded him to check all seven of her items. She tipped him \$20 dollars and rushed off.²

The skycap said that he had asked the woman whether the ice chest contained dry ice, a hazardous material with special limitations in air transportation.³ She did not declare that there were any hazardous materials in her baggage⁴ and later told investigators that she was not aware that hydrogen peroxide was a hazardous material. She checked in with Northwest at the gate and left Orlando on flight 957. There were no reports of incidents or injuries at the Orlando airport involving her baggage.

After flight 957 arrived in Memphis, two Northwest ramp employees entered the cargo compartments, between 0730 and 0745 central standard time, and began transferring the baggage to other aircraft in the morning bank of flights.⁵ Both employees noted wet baggage and a clear liquid on the floor. They assumed the liquid was water that had leaked from the ice chest or from a shipment of tropical fish.⁶

About 10 minutes after the baggage was unloaded, the employees who had handled the wet baggage and mail sacks began to complain that their hands were tingling and turning white. By then, some of the baggage had been transferred to other airplanes, and some had been returned to passengers. The ice chest and several bags had been loaded onto flight 7.

Because employees were complaining about their hands, Northwest contacted the airport's fire station, and it responded to the site. Northwest also contacted the airport's post office, which sent a postal employee to pick up the wet mail sacks. A ramp employee retrieved the ice chest from

² Northwest management indicated that the skycap was a Northwest employee and was authorized to collect the fees for extra baggage. Northwest took disciplinary action against the skycap.

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⁴ A search of her other baggage in Seattle revealed other undeclared hazardous materials, including small arms ammunition, an aerosol can of lubricant (a flammable gas), and a tube of gun oil (a combustible liquid).

⁵ Memphis is one of Northwest's hub airports. Northwest has 3 daily banks of about 40 flights; the planes are at the airport for only 1 to 2 hours.

⁶ According to the ramp employees, it is common to discover ice chests leaking due to melting ice. Also, live fish are shipped in plastic bags inside fiberboard boxes, and the bags occasionally break, spilling the water from the box.

flight 7. When he was told that the ice chest probably contained a hazardous material, he left to seek medical attention. After he left, the pilot of flight 7 noticed that there was a cluster of emergency responders and Northwest employees near the airplane. The pilot asked them about the nature of the emergency. They told him that the ice chest might contain a hazardous material. The pilot asked whether the ice chest had been on flight 7. Not knowing that the chest had been on flight 7, several Northwest employees told the pilot that it had not. Thinking that his airplane was not affected by the incident, the pilot of flight 7 departed as scheduled.

The emergency responders did an on-site examination and found that each bottle had split open and that the hydrogen peroxide had leaked from the bottles and the ice chest. Each bottle had a label that said "Vero Chemical Distributors, Inc.," and had generic warnings about flammable materials. The words "Hydrogen Peroxide" were handwritten in an upper corner of each label. When the responders questioned the passenger who had checked the ice chest, she told them that the bottles had contained a 35-percent solution of hydrogen peroxide.

During the emergency, the fire station responders used the *North American Emergency Response Guide* and a material safety data sheet⁷ about hydrogen peroxide as references. Northwest stated that it also contacted the Minnesota Poison Control Center.⁸ (While there is no record of the information provided by the center, a previous employee indicated that, given the nature of the center, its information would have focused on the medical hazards, including the fact that hydrogen peroxide can damage skin.) The information gathered described some of the hazards posed by hydrogen peroxide, but much of it did not point out that hydrogen peroxide that has dried on certain materials is a fire hazard. A fire station responder stated that the responders were concerned about the danger of fire from materials exposed to the oxidizing properties of hydrogen peroxide and had warned the Northwest employees.

Hydrogen peroxide is a very powerful oxidizing agent that can oxidize all organic compounds and a wide range of inorganic ones. It is not flammable, but it can readily cause other materials to burn. Natural materials like wood, paper, cotton, and leather are very susceptible to fire when exposed to hydrogen peroxide. These reactions are enhanced when the material contains dirt, especially metallic compounds of copper, silver, or mild steel.⁹ If a hydrogen peroxide solution is allowed to evaporate, the water evaporates more quickly than the hydrogen peroxide does, causing the solution to become more concentrated. As a hydrogen peroxide solution becomes more concentrated and is exposed to organic materials and dirt or metallic compounds, the hydrogen peroxide begins to decompose. This decomposition results in an exothermic reaction¹⁰ and the release of oxygen, which will support combustion.

The initial reaction of the baggage handlers to the clear water-like liquid in the cargo compartment of flight 957 was not unreasonable, given Northwest's indication that there are

⁷ A material safety data sheet is developed by the producer of a chemical product and contains general information about it, including a description of its chemical and physical properties, a description of the health and environmental hazards it poses, and guidelines for responding to its release.

⁸ At the time of the incident, the Minnesota Poison Control Center was under contract to Northwest to provide hazardous materials information.

⁹ Mild steel is a carbon steel with a maximum of about 0.25 percent carbon.

¹⁰ A chemical reaction that results in the generation and release of heat.

frequent spills of water from ice chests and tropical fish shipments. However, the Safety Board concludes that hydrogen peroxide presents a serious hazard to air transportation because it can be mistaken for water and can cause a fire if it is allowed to dry on cargo or baggage. Therefore, the Safety Board believes that the Federal Aviation Administration (FAA) should develop, with the assistance of the North American Hydrogen Peroxide Safety Producers Committee, and distribute to carriers guidance about the difficulty of identifying a hydrogen peroxide spill and about the danger of allowing hydrogen peroxide to dry on organic materials (including paper, fabric, cotton, and leather), which may result in a fire. The Safety Board has recommended that the North American Hydrogen Peroxide Safety Producers Committee assist the FAA in developing this guidance.

In the time between the discovery of the spill and the identification of the hazardous material, an undetermined number of bags potentially contaminated with hydrogen peroxide were transferred to 13 other Northwest aircraft for flights that departed Memphis, including flight 7 to Seattle. Northwest began making calls to Northwest management at all of the destination airports, initially focussing on airports receiving flights that had baggage transferred from flight 957. Callers provided information that focused on the injuries to the Memphis ground crew, first aid, and the need to use protective gloves when handling the baggage, and not on the fire hazard. It was recommended that people unloading the airplane check for wet baggage and, if it was discovered, condemn and replace it. A call was also made to Northwest's Systems Operations Control, which telexed information on the spill and a warning about potentially contaminated baggage to all Northwest operations offices, station managers, maintenance managers, and control centers. No similar warnings were sent to the pilots of the airplanes containing potentially contaminated baggage.

Before flight 7 landed in Seattle, the Northwest employees there knew that the airplane might be carrying contaminated baggage, and the baggage handlers, as Memphis had suggested, were protecting their hands with rubber gloves. However, no one in Seattle had independently researched the hazards posed by hydrogen peroxide, and the Northwest telephone call from Memphis had not mentioned fire hazards. Consequently, no one in Seattle was prepared for the possibility of a fire. The Northwest employees in Seattle had told the local emergency responders about the Memphis spill but had not asked any responders to stand by when flight 7 arrived in case there was a fire.

The baggage handlers reported that when they opened the cargo compartments of flight 7, they found smoke, but no flames, coming from the area of two adjacent suitcases. One handler said the smoke was "like someone blowing on a good cigar." The handlers backed away, and an equipment service employee without any protective equipment climbed into the compartment and retrieved the smoldering suitcases. Northwest called the fire department, which drowned the suitcases with water. A short time later, the equipment service employee became nauseated and was taken to a local hospital, where he was treated and released.

The Safety Board concludes that Northwest personnel in Memphis did not adequately address the nature of the emergency and allowed potentially contaminated baggage to be transferred to other aircraft. Once the employees' hands began to sting and turn white, Northwest should have immediately isolated all baggage, instead of returning it to passengers or transferring

it to other airplanes; and the baggage should have remained in isolation until the nature of the spilled material was determined. Had Northwest done so, the incident in Seattle would have been prevented. Therefore, the Safety Board has recommended that Northwest amend its emergency response procedures and training to include the importance of isolating baggage and cargo that have been involved with a hazardous materials spill until it can be determined which items have been contaminated and what measures are necessary to prevent further contamination of baggage and aircraft or other hazards (such as fire or poisoning).

Because the danger of this type of incident is not limited to Northwest, the Safety Board believes that the FAA should issue guidance to air carriers about the need to isolate baggage and cargo that have been involved with a hazardous materials spill until it can be determined which items have been contaminated and what measures are necessary to prevent further contamination of baggage and aircraft or other hazards (such as fire or poisoning). The Safety Board also believes that the FAA should require principal operations inspectors to review and amend, as necessary, air carrier manuals to ensure that air carrier procedures are consistent with the FAA's new guidance.

The Memphis incident did not have severe consequences; however, on February 3, 1988, American Airlines flight 132, a McDonnell Douglas DC-9-83, had an in-flight fire while en route to Tennessee from Texas.¹¹ The fire eventually breached the cargo compartment, and the passenger cabin floor over the middle cargo compartment was charred. The investigation determined that the fire had been caused by an undeclared and improperly packaged shipment of hydrogen peroxide. Further, according to the incident data base of the Research and Special Programs Administration, from 1995 through 1999, there were nine incidents involving hydrogen peroxide in air transportation.

The Safety Board concludes that given the potential for tragedy, Northwest failed to adequately alert aircraft flight crews. Several aircraft had departed before the emergency responders were able to determine what material had spilled. It is vitally important that the aircraft flight crew be notified in flight if any baggage on their airplane has been determined to have been involved in a hazardous materials spill. The flight crew should also be told how to prevent or mitigate an incident involving those materials. Therefore, the Safety Board has recommended that Northwest amend its emergency response procedures and training to include notification of pilots in flight when baggage and cargo that are believed to have been involved in a hazardous materials spill have been placed on their aircraft; notifying the pilots includes clearly identifying the hazards posed by the material involved in the spill and the procedures that the pilots should take.

Because the danger of this type of incident is not limited to Northwest, the Safety Board believes that the FAA should issue guidance to air carriers about the need to notify pilots in flight when baggage and cargo that are believed to have been involved in a hazardous materials spill have been placed on their aircraft; notifying the pilots includes clearly identifying the hazards posed by the material involved in the spill and the procedures that the pilots should take. The

¹¹ National Transportation Safety Board. 1988. *In-flight Fire, McDonnell Douglas DC-9-83, N569AA, Nashville Metropolitan Airport, Nashville, Tennessee, February 3, 1988*, Hazardous Materials Incident Report NTSB/HZM-88/02. Washington, D.C.

Safety Board believes that the FAA then should require principal operations inspectors to review and amend, as necessary, air carrier manuals to ensure that air carrier procedures are consistent with this guidance.

As a result of this investigation, the National Transportation Safety Board recommends that the Federal Aviation Administration:

Develop, with the assistance of the Hydrogen Peroxide Safety Producers Committee, and distribute to carriers guidance about the difficulty of identifying a hydrogen peroxide spill and about the danger of allowing hydrogen peroxide to dry on organic materials (including paper, fabric, cotton, and leather), which may result in a fire. (A-00-51)

Issue guidance to air carriers about the need to isolate baggage and cargo that have been involved with a hazardous materials spill until it can be determined which items have been contaminated and what measures are necessary to prevent further contamination of baggage and aircraft or other hazards (such as fire or poisoning). Then require principal operations inspectors to review and amend, as necessary, air carrier manuals to ensure that air carrier procedures are consistent with this guidance. (A-00-52)

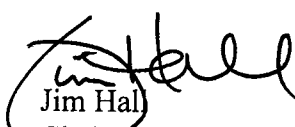
Issue guidance to air carriers about the need to notify pilots in flight when baggage and cargo that are believed to have been involved in a hazardous materials spill have been placed on their aircraft; notifying the pilots includes clearly identifying the hazards posed by the material involved in the spill and the procedures that the pilots should take. Then require principal operations inspectors to review and amend, as necessary, air carrier manuals to ensure that air carrier procedures are consistent with this guidance. (A-00-53)

The Safety Board also issued seven other safety recommendations, one to the U.S. Postal Service, three to Northwest Airlines, Inc., two to the Hydrogen Peroxide Safety Producers Association, and one to the Air Transport Association.

Please refer to Safety Recommendations A-00-51 through -53 in your reply. If you need additional information, you may call (202) 314-6170.

Chairman HALL and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

By:


Jim Hall
Chairman



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: June 8, 2000

In reply refer to: A-00-54

Honorable William Henderson
Postmaster General and Chief Executive Officer
U.S. Postal Service
475 L'Enfant Plaza, S.W.
Washington, D.C. 20260-0010

The National Transportation Safety Board is an independent Federal agency charged by Congress with investigating transportation accidents, determining their probable cause, and making recommendations to prevent similar accidents from occurring. We are providing the following information to urge your organization to take action on the safety recommendation in this letter. The Safety Board is vitally interested in this recommendation because it is designed to prevent accidents and save lives.

This recommendation addresses the adequacy of U.S. Postal Service procedures for responding to hazardous material spills. The recommendation is derived from the Safety Board's investigation of the October 28, 1998, spill of hydrogen peroxide in a cargo compartment on Northwest Airlines (Northwest) flight 957 while it was en route from Orlando, Florida, to Memphis, Tennessee, and is consistent with the evidence we found and the analysis we performed. As a result of this investigation, the Safety Board has issued ten safety recommendations, one of which is addressed to the U.S. Postal Service. Information supporting the recommendation is discussed below. The Safety Board would appreciate a response from you within 90 days addressing the actions you have taken or intend to take to implement our recommendation.

On the morning of October 28, 1998, 2 gallons of a 35-percent hydrogen peroxide solution in water, an oxidizer¹ with corrosive properties, spilled in a cargo compartment of Northwest flight 957, a passenger-carrying airplane en route from Orlando to Memphis. The solution leaked from two undeclared 1-gallon plastic bottles that had split. The bottles were in an ice chest that belonged to a passenger on the flight. The leaking hydrogen peroxide contaminated three mail sacks and an undetermined number of bags.

¹ The Department of Transportation defines an oxidizer as "a material that may, generally by yielding oxygen, cause or enhance the combustion of other materials."

The leak was not discovered until cargo handlers in Memphis began to unload the baggage on flight 957. Thinking that the spilled liquid was water, the cargo handlers ignored it and transferred some of the baggage to other Northwest passenger-carrying flights, including flight 7, which then departed for Seattle, Washington. When flight 7 arrived in Seattle, two bags in a cargo compartment were smoldering, including one that had come from flight 957.

As a result of the spill, several people required treatment. In Memphis, 11 employees were treated at the airport's first aid station because their hands had been exposed to the hydrogen peroxide, and 2 more employees went to a local clinic, where they were treated and released. In Seattle, the employee who removed the smoldering bags from the cargo compartment was exposed to fumes. He went to a hospital for treatment and was released. None of the injuries were serious. Northwest estimated that the total cost of the damage to and the downtime on the aircraft and of the damage to the baggage was more than \$40,000.

The National Transportation Safety Board determines that the probable cause of the release of undeclared hazardous material aboard Northwest Airlines flight 957 was the passenger's failure to properly package and identify the hazardous material and inadequate inquiries from the Northwest Airlines agent about the contents of the cooler offered by the passenger. Contributing to the consequences of the incident were inadequate carrier procedures for handling a hazardous materials cargo spill.

The passenger who had checked the ice chest at Orlando was a nurse. She had bought the hydrogen peroxide containers several years earlier and stored them unopened at an assisted care facility for the elderly in Fort Pierce, Florida, that she had once owned. Before her trip on flight 957, she had packed the two plastic bottles of hydrogen peroxide in a plastic ice chest with some sand and a bag of rolls.

She arrived at the airport at 0600 eastern standard time (EST); the flight was scheduled to depart at 0630 EST. She attempted to check seven items, including the ice chest, at Northwest's roadside skycap service. According to the skycap, he had been reluctant to check the bags because Northwest allows a passenger to have only two items checked without paying additional fees. He had told her that the fees must be paid at the ticket counter inside the terminal, but she explained that she was late and persuaded him to check all seven of her items. She tipped him \$20 dollars and rushed off.²

The skycap said that he had asked the woman whether the ice chest contained dry ice, a hazardous material with special limitations in air transportation.³ She did not declare that there were any hazardous materials in her baggage⁴ and later told investigators that she was not aware that hydrogen peroxide was a hazardous material. She checked in with Northwest at the gate and

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³ Northwest hazardous materials training specifically addresses questioning passengers about hazardous materials in ice chests.

⁴ A search of her other baggage in Seattle revealed other undeclared hazardous materials, including small arms ammunition, an aerosol can of lubricant (a flammable gas), and a tube of gun oil (a combustible liquid).

left Orlando on flight 957. There were no reports of incidents or injuries at the Orlando airport involving her baggage.

After flight 957 arrived in Memphis, two Northwest ramp employees entered the cargo compartments, between 0730 and 0745 central standard time, and began transferring the baggage to other aircraft in the morning bank of flights.⁵ Both employees noted wet baggage and a clear liquid on the floor. They assumed the liquid was water that had leaked from the ice chest or from a shipment of tropical fish.⁶

About 10 minutes after the baggage was unloaded, the employees who had handled the wet baggage and mail sacks began to complain that their hands were tingling and turning white. By then, some of the baggage had been transferred to other airplanes, and some had been returned to passengers. The ice chest and several bags had been loaded onto flight 7.

Because employees were complaining about their hands, Northwest contacted the airport's fire station, and it responded to the site. Northwest also contacted the airport's post office, which sent a postal employee to pick up the wet mail sacks. A ramp employee retrieved the ice chest from flight 7. When he was told that the ice chest probably contained a hazardous material, he left to seek medical attention. After he left, the pilot of flight 7 noticed that there was a cluster of emergency responders and Northwest employees near the airplane. The pilot asked them about the nature of the emergency. They told him that the ice chest might contain a hazardous material. The pilot asked whether the ice chest had been on flight 7. Not knowing that the chest had been on flight 7, several Northwest employees told the pilot that it had not. Thinking that his airplane was not affected by the incident, the pilot of flight 7 departed as scheduled.

The emergency responders did an on-site examination and found that each bottle had split open and that the hydrogen peroxide had leaked from the bottles and the ice chest. Each bottle had a label that said "Vero Chemical Distributors, Inc.," and had generic warnings about flammable materials. The words "Hydrogen Peroxide" were handwritten in an upper corner of each label. When the responders questioned the passenger who had checked the ice chest, she told them that the bottles had contained a 35-percent solution of hydrogen peroxide.

During the emergency, the fire station responders used the *North American Emergency Response Guide* and a material safety data sheet⁷ about hydrogen peroxide as references. Northwest stated that it also contacted the Minnesota Poison Control Center.⁸ (While there is no record of the information provided by the center, a previous employee indicated that, given the nature of the center, its information would have focused on the medical hazards, including the fact that hydrogen

⁵ Memphis is one of Northwest's hub airports. Northwest has 3 daily banks of about 40 flights; the planes are at the airport for only 1 to 2 hours.

⁶ According to the ramp employees, it is common to discover ice chests leaking due to melting ice. Also, live fish are shipped in plastic bags inside fiberboard boxes, and the bags occasionally break, spilling the water from the box.

⁷ A material safety data sheet is developed by the producer of a chemical product and contains general information about it, including a description of its chemical and physical properties, a description of the health and environmental hazards it poses, and guidelines for responding to its release.

⁸ At the time of the incident, the Minnesota Poison Control Center was under contract to Northwest to provide hazardous materials information.

peroxide can damage skin.) Some of the information gathered described hazards posed by hydrogen peroxide, but much of it did not point out that hydrogen peroxide that has dried on certain materials is a fire hazard. A fire station responder stated that the responders were concerned about the danger of fire from materials exposed to the oxidizing properties of hydrogen peroxide and had warned the Northwest employees.

Hydrogen peroxide is a very powerful oxidizing agent that can oxidize all organic compounds and a wide range of inorganic ones. It is not flammable, but it can readily cause other materials to burn. Natural materials like wood, paper, cotton, and leather are very susceptible to fire when exposed to hydrogen peroxide. These reactions are enhanced when the material contains dirt, especially metallic compounds of copper, silver, or mild steel.⁹ If a hydrogen peroxide solution is allowed to evaporate, the water evaporates more quickly than the hydrogen peroxide does, causing the solution to become more concentrated. As a hydrogen peroxide solution becomes more concentrated and is exposed to organic materials and dirt or metallic compounds, the hydrogen peroxide begins to decompose. This decomposition results in an exothermic reaction¹⁰ and the release of oxygen, which will support combustion.

The post office employee who picked up the wet mail sacks called a post office safety officer in the central Memphis post office to report that the mail sacks were contaminated with a liquid. The safety officer told him to isolate the mail sacks on the docks until he, the safety officer, arrived. By the time he arrived, the contamination had been identified as hydrogen peroxide. He then said that the mail should be dumped from the nylon sacks into large open wire bins and allowed to dry outside. That evening, after the mail had dried outside, it was shipped by ground transportation to its destination, Kansas City, Missouri. The safety officer said that he was familiar with hydrogen peroxide and did not refer to any specific information on the hazards or properties of the chemical in determining the actions to be taken.¹¹ The Postal Service did not have any subsequent incidents involving the contaminated mail.

Given that two bags on flight 7 began to smolder and given the fact that allowing hydrogen peroxide to dry on materials, including paper, can result in a fire, a hydrogen peroxide spill can present a serious fire hazard in the mail if it is allowed to dry on letters or packages. The Safety Board concludes that the post office safety officer did not follow Postal Service training that instructed him to determine the hazards of chemical spills by using technical information, including material safety data sheets, about the hazards and the chemical properties of materials before he responded to the hydrogen peroxide contamination on the mail. As a result, the Safety Board believes that the Postal Service should reinforce the training provided to its hazardous materials emergency responders concerning the need to use technical information, including material safety data sheets, about the hazards and the chemical properties of materials when responding to a spill instead of relying solely on memory or previous experience.

⁹ Mild steel is a carbon steel with a maximum of about 0.25 percent carbon.

¹⁰ A chemical reaction that results in the generation and release of heat.

¹¹ Postal Service training material about hazardous materials emergency response states that postal employees responding to a hazardous materials spill should determine the hazards of the material by using material data safety sheets and other information.

The Federal Aviation Administration has initiated enforcement action against the Northwest passenger for violating the Hazardous Materials Regulations.¹²


As a result of this investigation, the National Transportation Safety Board recommends that the U.S. Postal Service:

Reinforce the training provided to your hazardous materials emergency responders concerning the need to use technical information, including material safety data sheets, about the hazards and the chemical properties of materials when responding to a spill instead of relying solely on memory or previous experience.
(A-00-54)

The Safety Board also issued safety recommendations to the Federal Aviation Administration, the Hydrogen Peroxide Safety Producers Committee, Northwest Airlines, Inc., and the Air Transport Association. In your response to the recommendation in this letter, please refer to Safety Recommendation A-00-54. If you need additional information, you may call (202) 314-6170.

Chairman HALL and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in this recommendation.

By:



Jim Hall
Chairman

¹² Title 49 *Code of Federal Regulations* (CFR) Subchapter "C."



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: June 8, 2000

In reply refer to: A-00-55

Ms. Carol B. Hallett
President and Chief Executive Officer
Air Transport Association
1301 Pennsylvania Avenue, N.W.
Suite 1100
Washington, D.C. 20004-1707

The National Transportation Safety Board is an independent Federal agency charged by Congress with investigating transportation accidents, determining their probable cause, and making recommendations to prevent similar accidents from occurring. We are providing the following information to urge your organization to take action on the safety recommendation in this letter. The Safety Board is vitally interested in this recommendation because it is designed to prevent accidents and save lives.

This recommendation addresses the adequacy of emergency response guidelines, procedures, and training for responding to a hydrogen peroxide spill and the adequacy of air carrier procedures for responding to hazardous material spills. The recommendation is derived from the Safety Board's investigation of the October 28, 1998, spill of hydrogen peroxide in a cargo compartment on Northwest Airlines (Northwest) flight 957 while it was en route from Orlando, Florida, to Memphis, Tennessee, and is consistent with the evidence we found and the analysis we performed. As a result of this investigation, the Safety Board has issued ten safety recommendations, one of which is addressed to the Air Transport Association. Information supporting the recommendation is discussed below. The Safety Board would appreciate a response from you within 90 days addressing the actions you have taken or intend to take to implement our recommendation.

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As a result of the spill, several people required treatment. In Memphis, 11 employees were treated at the airport's first aid station because their hands had been exposed to the hydrogen peroxide, and 2 more employees went to a local clinic, where they were treated and released. In Seattle, the employee who removed the smoldering bags from the cargo compartment was exposed to fumes. He went to a hospital for treatment and was released. None of the injuries were serious. Northwest estimated that the total cost of the damage to and the downtime on the aircraft and of the damage to the baggage was more than \$40,000.

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About 10 minutes after the baggage was unloaded, the employees who had handled the wet baggage and mail sacks began to complain that their hands were tingling and turning white. By then, some of the baggage had been transferred to other airplanes, and some had been returned to passengers. The ice chest and several bags had been loaded onto flight 7.

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⁸ At the time of the incident, the Minnesota Poison Control Center was under contract to Northwest to provide hazardous materials information.

peroxide can damage skin.) The information gathered described some of the hazards posed by hydrogen peroxide, but much of it did not point out that hydrogen peroxide that has dried on certain materials is a fire hazard. A fire station responder stated that the responders were concerned about the danger of fire from materials exposed to the oxidizing properties of hydrogen peroxide and had warned the Northwest employees.

Hydrogen peroxide is a very powerful oxidizing agent that can oxidize all organic compounds and a wide range of inorganic ones. It is not flammable, but it can readily cause other materials to burn. Natural materials like wood, paper, cotton, and leather are very susceptible to fire when exposed to hydrogen peroxide. These reactions are enhanced when the material contains dirt, especially metallic compounds of copper, silver, or mild steel.⁹ If a hydrogen peroxide solution is allowed to evaporate, the water evaporates more quickly than the hydrogen peroxide does, causing the solution to become more concentrated. As a hydrogen peroxide solution becomes more concentrated and is exposed to organic materials and dirt or metallic compounds, the hydrogen peroxide begins to decompose. This decomposition results in an exothermic reaction¹⁰ and the release of oxygen, which will support combustion.

The initial reaction of the baggage handlers to the clear water-like liquid in the cargo compartment of flight 957 was not unreasonable, given Northwest's indication that there are frequent spills of water from ice chests and tropical fish shipments. However, the Safety Board concludes that hydrogen peroxide presents a serious hazard to air transportation because it can be mistaken for water and can cause a fire if it is allowed to dry on cargo or baggage. Therefore, the Safety Board has recommended that the Federal Aviation Administration (FAA) develop, with the assistance of the North American Hydrogen Peroxide Safety Producers Committee, and distribute to carriers guidance about the difficulty of identifying a hydrogen peroxide spill and about the danger of allowing hydrogen peroxide to dry on organic materials (including paper, fabric, cotton, and leather), which may result in a fire. The Safety Board has also recommended that the North American Hydrogen Peroxide Safety Producers Committee assist the FAA in developing this guidance.

In the time between the discovery of the spill and the identification of the hazardous material, an undetermined number of bags potentially contaminated with hydrogen peroxide were transferred to 13 other Northwest aircraft for flights that departed Memphis, including flight 7 to Seattle. Northwest began making calls to Northwest management at all of its destination airports, initially focussing on airports receiving flights that had baggage transferred from flight 957. Callers provided information that focused on the injuries to the Memphis ground crew, first aid, and the need to use protective gloves when handling the baggage, and not on the fire hazard. It was recommended that people unloading the airplane check for wet baggage and, if it was discovered, condemn and replace it. A call was also made to Northwest's Systems Operations Control, which telexed information on the spill and a warning about potentially contaminated baggage to all Northwest operations offices, station managers, maintenance managers, and control centers. No similar warnings were sent to the pilots of the airplanes containing potentially contaminated baggage.

⁹ Mild steel is a carbon steel with a maximum of about 0.25 percent carbon.

¹⁰ A chemical reaction that results in the generation and release of heat.

Before flight 7 landed in Seattle, the Northwest employees there knew that the airplane might be carrying contaminated baggage, and the baggage handlers, as Memphis had suggested, were protecting their hands with rubber gloves. However, no one in Seattle had independently researched the hazards posed by hydrogen peroxide, and the Northwest telephone call from Memphis had not mentioned fire hazards. Consequently, no one in Seattle was prepared for the possibility of a fire. The Northwest employees in Seattle had told the local emergency responders about the Memphis spill but had not asked any responders to stand by when flight 7 arrived in case there was a fire.

The baggage handlers reported that when they opened the cargo compartments of flight 7, they found smoke, but no flames, coming from the area of two adjacent suitcases. One handler said the smoke was "like someone blowing on a good cigar." The handlers backed away, and an equipment service employee without any protective equipment climbed into the compartment and retrieved the smoldering suitcases. Northwest called the fire department, which drowned the suitcases with water. A short time later, the equipment service employee became nauseated and was taken to a local hospital, where he was treated and released.

The Safety Board concludes that Northwest personnel in Memphis did not adequately address the nature of the emergency and allowed potentially contaminated baggage to be transferred to other aircraft. Once the employees' hands began to sting and turn white, Northwest should have immediately isolated all baggage, instead of returning it to passengers or transferring it to other airplanes; and the baggage should have remained in isolation until the nature of the spilled material was determined. Had Northwest done so, the incident in Seattle would have been prevented. Therefore, the Safety Board has recommended that Northwest amend its emergency response procedures and training to include the importance of isolating baggage and cargo that have been involved with a hazardous materials spill until it can be determined which items have been contaminated and what measures are necessary to prevent further contamination of baggage and aircraft or other hazards (such as fire or poisoning).

Because the danger of this type of incident is not limited to Northwest, the Safety Board has recommended that the FAA issue guidance to air carriers about the need to isolate baggage and cargo that have been involved with a hazardous materials spill until it can be determined which items have been contaminated and what measures are necessary to prevent further contamination of baggage and aircraft or other hazards (such as fire or poisoning). The Safety Board has also recommended that the FAA require principal operations inspectors to review and amend, as necessary, air carrier manuals to ensure that air carrier procedures are consistent with the FAA's new guidance.

The Memphis incident did not have severe consequences; however, on February 3, 1988, American Airlines flight 132, a McDonnell Douglas DC-9-83, had an in-flight fire while en route to Tennessee from Texas.¹¹ The fire eventually breached the cargo compartment, and the passenger cabin floor over the middle cargo compartment was charred. The investigation determined that the fire had been caused by an undeclared and improperly packaged shipment of

¹¹ National Transportation Safety Board. 1988. *In-flight Fire, McDonnell Douglas DC-9-83, N569AA, Nashville Metropolitan Airport, Nashville, Tennessee, February 3, 1988*, Hazardous Materials Incident Report NTSB/HZM-88/02. Washington, D.C.

hydrogen peroxide. Further, according to the incident data base of the Research and Special Programs Administration, from 1995 through 1999, there were nine incidents involving hydrogen peroxide in air transportation.

The Safety Board concludes that given the potential for tragedy, Northwest failed to adequately alert aircraft flight crews. Several aircraft had departed before the emergency responders were able to determine what material had spilled. It is vitally important that the aircraft flight crew be notified in flight if any baggage on their airplane has been determined to have been involved in a hazardous materials spill. The flight crew should also be told how to prevent or mitigate an incident involving those materials. Therefore, the Safety Board has recommended that Northwest amend its emergency response procedures and training to include notification of pilots in flight when baggage and cargo that are believed to have been involved in a hazardous materials spill have been placed on their aircraft; notifying the pilots includes clearly identifying the hazards posed by the material involved in the spill and the procedures that the pilots should take.

Further, because the danger of this type of incident is not limited to Northwest, the Safety Board has recommended that the FAA issue guidance to air carriers about the need to notify pilots in flight when baggage and cargo that are believed to have been involved in a hazardous materials spill have been placed on their aircraft; notifying the pilots includes clearly identifying the hazards posed by the material involved in the spill and the procedures that the pilots should take. The Safety Board has recommended that the FAA then require principal operations inspectors to review and amend, as necessary, air carrier manuals to ensure that air carrier procedures are consistent with this guidance.

Given the potential that contaminated baggage and cargo have to cause a tragedy and given your organization's unique position in the industry, the Safety Board believes that the Air Transport Association should inform its members about the Memphis incident and make them aware of the following: the difficulty of identifying a hydrogen peroxide spill; the danger of allowing hydrogen peroxide to dry on organic materials; the need to isolate baggage and cargo that have been involved with a hazardous materials spill until it can be determined which items have been contaminated and what measures are necessary to prevent further contamination of baggage and aircraft or other hazards (such as fire or poisoning); and the need to notify pilots in flight when baggage and cargo that are believed to have been involved in a hazardous materials spill have been placed on their aircraft (such notification includes informing the pilots clearly about the hazards presented by the material involved in the spill and the procedures that the pilots should take).

The FAA has initiated action against the passenger for violating the Hazardous Materials Regulations.¹²

As a result of this investigation, the National Transportation Safety Board recommends that the Air Transport Association:

¹² Title 49 *Code of Federal Regulations* Subchapter "C."

Inform your members about the Memphis incident and make them aware of the following: the difficulty of identifying a hydrogen peroxide spill; the danger of allowing hydrogen peroxide to dry on organic materials; the need to isolate baggage and cargo that have been involved with a hazardous materials spill until it can be determined which items have been contaminated and what measures are necessary to prevent further contamination of baggage and aircraft or other hazards (such as fire or poisoning); and the need to notify pilots in flight when baggage and cargo that are believed to have been involved in a hazardous materials spill have been placed on their aircraft (such notification includes informing the pilots clearly about the hazards presented by the material involved in the spill and the procedures that the pilots should take). (A-00-55)

The Safety Board also issued safety recommendations to the Federal Aviation Administration, the U.S. Postal Service, the Hydrogen Peroxide Safety Producers Committee, and Northwest Airlines, Inc. In your response to the recommendation in this letter, please refer to Safety Recommendation A-00-55. If you need additional information, you may call (202) 314-6170.

Chairman HALL and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in this recommendation.

By: 
Jim Hall
Chairman



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: June 8, 2000

In reply refer to: A-00-56 through -58

Mr. John Dasburg
President and Chief Executive Officer
Northwest Airlines, Inc.
Mail Stop A1020
5101 Northwest Drive
St. Paul, Minnesota 55111

The National Transportation Safety Board is an independent Federal agency charged by Congress with investigating transportation accidents, determining their probable cause, and making recommendations to prevent similar accidents from occurring. We are providing the following information to urge your organization to take action on the safety recommendations in this letter. The Safety Board is vitally interested in these recommendations because they are designed to prevent accidents and save lives.

These recommendations address the adequacy of emergency response guidelines, procedures, and training for responding to a hydrogen peroxide spill and the adequacy of air carrier procedures for responding to hazardous material spills. The recommendations are derived from the Safety Board's investigation of the October 28, 1998, spill of hydrogen peroxide in a cargo compartment on Northwest Airlines (Northwest) flight 957 while it was en route from Orlando, Florida, to Memphis, Tennessee, and are consistent with the evidence we found and the analysis we performed. As a result of this investigation, the Safety Board has issued ten safety recommendations, three of which are addressed to Northwest Airlines, Inc. Information supporting the recommendations is discussed below. The Safety Board would appreciate a response from you within 90 days addressing the actions you have taken or intend to take to implement our recommendations.

On the morning of October 28, 1998, 2 gallons of a 35-percent hydrogen peroxide solution in water, an oxidizer¹ with corrosive properties, spilled in a cargo compartment of Northwest flight 957, a passenger-carrying airplane en route from Orlando to Memphis. The solution leaked from two undeclared 1-gallon plastic bottles that had split. The bottles were in an ice chest that belonged to a passenger on the flight. The leaking hydrogen peroxide contaminated three mail sacks and an undetermined number of bags.

¹ The Department of Transportation defines an oxidizer as "a material that may, generally by yielding oxygen, cause or enhance the combustion of other materials."

The leak was not discovered until cargo handlers in Memphis began to unload the baggage on flight 957. Thinking that the spilled liquid was water, the cargo handlers ignored it and transferred some of the baggage to other Northwest passenger-carrying flights, including flight 7, which then departed for Seattle, Washington. When flight 7 arrived in Seattle, two bags in a cargo compartment were smoldering, including one that had come from flight 957.

As a result of the spill, several people required treatment. In Memphis, 11 employees were treated at the airport's first aid station because their hands had been exposed to the hydrogen peroxide, and 2 more employees went to a local clinic, where they were treated and released. In Seattle, the employee who removed the smoldering bags from the cargo compartment was exposed to fumes. He went to a hospital for treatment and was released. None of the injuries were serious. Northwest estimated that the total cost of the damage to and the downtime on the aircraft and of the damage to the baggage was more than \$40,000.

The National Transportation Safety Board determines that the probable cause of the release of undeclared hazardous material aboard Northwest Airlines flight 957 was the passenger's failure to properly package and identify the hazardous material and inadequate inquiries from the Northwest Airlines agent about the contents of the cooler offered by the passenger. Contributing to the consequences of the incident were inadequate carrier procedures for handling a hazardous materials cargo spill.

The passenger who had checked the ice chest at Orlando was a nurse. She had bought the hydrogen peroxide containers several years earlier and stored them unopened at an assisted care facility for the elderly in Fort Pierce, Florida, that she had once owned. Before her trip on flight 957, she had packed the two plastic bottles of hydrogen peroxide in a plastic ice chest with some sand and a bag of rolls.

She arrived at the airport at 0600 eastern standard time (EST); the flight was scheduled to depart at 0630 EST. She attempted to check seven items, including the ice chest, at Northwest's roadside skycap service. According to the skycap, he had been reluctant to check the bags because Northwest allows a passenger to have only two items checked without paying additional fees. He had told her that the fees must be paid at the ticket counter inside the terminal, but she explained that she was late and persuaded him to check all seven of her items. She tipped him \$20 dollars and rushed off.

The skycap said that he had asked the woman whether the ice chest contained dry ice, a hazardous material with special limitations in air transportation.² She did not declare that there were any hazardous materials in her baggage³ and later told investigators that she was not aware that hydrogen peroxide was a hazardous material. She checked in with Northwest at the gate and left Orlando on flight 957. There were no reports of incidents or injuries at the Orlando airport involving her baggage.

² Northwest hazardous materials training specifically addresses questioning passengers about hazardous materials in ice chests.

³ A search of her other baggage in Seattle revealed other undeclared hazardous materials, including small arms ammunition, an aerosol can of lubricant (a flammable gas), and a tube of gun oil (a combustible liquid).

After flight 957 arrived in Memphis, two Northwest ramp employees entered the cargo compartments, between 0730 and 0745 central standard time, and began transferring the baggage to other aircraft in the morning bank of flights. Both employees noted wet baggage and a clear liquid on the floor. They assumed the liquid was water that had leaked from the ice chest or from a shipment of tropical fish.⁴

About 10 minutes after the baggage was unloaded, the employees who had handled the wet baggage and mail sacks began to complain that their hands were tingling and turning white. By then, some of the baggage had been transferred to other airplanes, and some had been returned to passengers. The ice chest and several bags had been loaded onto flight 7.

Because employees were complaining about their hands, Northwest contacted the airport's fire station, and it responded to the site. Northwest also contacted the airport's post office, which sent a postal employee to pick up the wet mail sacks. A ramp employee retrieved the ice chest from flight 7. When he was told that the ice chest probably contained a hazardous material, he left to seek medical attention. After he left, the pilot of flight 7 noticed that there was a cluster of emergency responders and Northwest employees near the airplane. The pilot asked them about the nature of the emergency. They told him that the ice chest might contain a hazardous material. The pilot asked whether the ice chest had been on flight 7. Not knowing that the chest had been on flight 7, several Northwest employees told the pilot that it had not. Thinking that his airplane was not affected by the incident, the pilot of flight 7 departed as scheduled.

The emergency responders did an on-site examination and found that each bottle had split open and that the hydrogen peroxide had leaked from the bottles and the ice chest. Each bottle had a label that said "Vero Chemical Distributors, Inc.," and had generic warnings about flammable materials. The words "Hydrogen Peroxide" were handwritten in an upper corner of each label. When the responders questioned the passenger who had checked the ice chest, she told them that the bottles had contained a 35-percent solution of hydrogen peroxide.

During the emergency, the fire station responders used the *North American Emergency Response Guide* and a material safety data sheet⁵ about hydrogen peroxide as references. Northwest stated that it also contacted the Minnesota Poison Control Center.⁶ (While there is no record of the information provided by the center, a previous employee indicated that, given the nature of the center, its information would have focused on the medical hazards, including the fact that hydrogen peroxide can damage skin.) The information gathered described some of the hazards posed by hydrogen peroxide, but much of it did not point out that hydrogen peroxide that has dried on certain materials is a fire hazard. A fire station responder stated that the responders were concerned about

⁴ According to the ramp employees, it is common to discover ice chests leaking due to melting ice. Also, live fish are shipped in plastic bags inside fiberboard boxes, and the bags occasionally break, spilling the water from the box.

⁵ A material safety data sheet is developed by the producer of a chemical product and contains general information about it, including a description of its chemical and physical properties, a description of the health and environmental hazards it poses, and guidelines for responding to its release.

⁶ At the time of the incident, the Minnesota Poison Control Center was under contract to Northwest to provide hazardous materials information.

the danger of fire from materials exposed to the oxidizing properties of hydrogen peroxide and had warned the Northwest employees.

Hydrogen peroxide is a very powerful oxidizing agent that can oxidize all organic compounds and a wide range of inorganic ones. It is not flammable, but it can readily cause other materials to burn. Natural materials like wood, paper, cotton, and leather are very susceptible to fire when exposed to hydrogen peroxide. These reactions are enhanced when the material contains dirt, especially metallic compounds of copper, silver, or mild steel.⁷ If a hydrogen peroxide solution is allowed to evaporate, the water evaporates more quickly than the hydrogen peroxide does, causing the solution to become more concentrated. As a hydrogen peroxide solution becomes more concentrated and is exposed to organic materials and dirt or metallic compounds, the hydrogen peroxide begins to decompose. This decomposition results in an exothermic reaction⁸ and the release of oxygen, which will support combustion.

In the time between the discovery of the spill and the identification of the hazardous material, an undetermined number of bags potentially contaminated with hydrogen peroxide were transferred to 13 other Northwest aircraft for flights that departed Memphis, including flight 7 to Seattle. Northwest began making calls to Northwest management at all of their destination airports, initially focussing on airports receiving flights that had baggage transferred from flight 957. Callers provided information that focussed on the injuries to the Memphis ground crew, first aid, and the need to use protective gloves when handling the baggage, and not on the fire hazard. It was recommended that people unloading the airplane check for wet baggage and, if it was discovered, condemn and replace it. A call was also made to Northwest's Systems Operations Control, which telexed information on the spill and a warning about potentially contaminated baggage to all Northwest operations offices, station managers, maintenance managers, and control centers. No similar warnings were sent to the pilots of the aircraft containing potentially contaminated baggage.

Before flight 7 landed in Seattle, the Northwest employees there knew that the airplane might be carrying contaminated baggage, and the baggage handlers, as Memphis had suggested, were protecting their hands with rubber gloves. However, no one in Seattle had independently researched the hazards posed by hydrogen peroxide, and the Northwest telephone call from Memphis had not mentioned fire hazards. Consequently, no one in Seattle was prepared for the possibility of a fire. The Northwest employees in Seattle had told the local emergency responders about the Memphis spill but had not asked any responders to stand by when flight 7 arrived in case there was a fire.

The baggage handlers reported that when they opened the cargo compartments of flight 7, they found smoke, but no flames, coming from the area of two adjacent suitcases. One handler said the smoke was "like someone blowing on a good cigar." The handlers backed away, and an equipment service employee without any protective equipment climbed into the compartment and retrieved the smoldering suitcases. Northwest called the fire department, which drowned the

⁷ Mild steel is a carbon steel with a maximum of about 0.25 percent carbon.

⁸ A chemical reaction that results in the generation and release of heat.

suitcases with water. A short time later, the equipment service employee became nauseated and was taken to a local hospital, where he was treated and released.

Northwest's ground operations personnel are trained to react to a fire in an aircraft by calling the fire department from a safe location and by closing exterior doors to prevent the spread of fire inside the aircraft. Some ground operations personnel are not trained in what actions to take when hazardous materials are spilled in cargo compartments. The Safety Board concludes that when the equipment service employee failed to follow Northwest's training concerning fires inside aircraft and entered the cargo compartment to retrieve the smoldering bags, he placed himself in danger of serious injury from smoke and possible exposure to a hazardous material; he knew that the bags could have been contaminated with a hazardous material. The Safety Board believes that Northwest should reinforce the training provided to ground operations and maintenance personnel on actions to take for a suspected fire in an aircraft cargo compartment. Also, for those employees, Northwest should review and modify, as appropriate, procedures and training for a suspected hazardous materials spill in an aircraft cargo compartment.

The Safety Board concludes that Northwest personnel in Memphis did not adequately address the nature of the emergency and allowed potentially contaminated baggage to be transferred to other aircraft. Once the employees' hands began to sting and turn white, Northwest should have immediately isolated all baggage, instead of returning it to passengers or transferring it to other airplanes; and the baggage should have remained in isolation until the nature of the spilled material was determined. Had Northwest done so, the incident in Seattle would have been prevented. Therefore, the Safety Board believes that Northwest should amend its emergency response procedures and training to include the importance of isolating baggage and cargo that have been involved with a hazardous materials spill until it can be determined which items have been contaminated and what measures are necessary to prevent further contamination of baggage and aircraft or other hazards (such as fire or poisoning).

Because the danger of this type of incident is not limited to Northwest, the Safety Board has recommended that the Federal Aviation Administration (FAA) issue guidance to air carriers about the need to isolate baggage and cargo that have been involved with a hazardous materials spill until it can be determined which items have been contaminated and what measures are necessary to prevent further contamination of baggage and aircraft or other hazards (such as fire or poisoning). The Safety Board has also recommended that the FAA require principal operations inspectors to review and amend, as necessary, air carrier manuals to ensure that air carrier procedures are consistent with the FAA's new guidance.

The Memphis incident did not have severe consequences; however, on February 3, 1988, American Airlines flight 132, a McDonnell Douglas DC-9-83, had an in-flight fire while en route to Tennessee from Texas.⁹ The fire eventually breached the cargo compartment, and the passenger cabin floor over the middle cargo compartment was charred. The investigation determined that the fire had been caused by an undeclared and improperly packaged shipment of

⁹ National Transportation Safety Board. 1988. *In-flight Fire, McDonnell Douglas DC-9-83, N569AA, Nashville Metropolitan Airport, Nashville, Tennessee, February 3, 1988*, Hazardous Materials Incident Report NTSB/HZM-88/02. Washington, D.C.

hydrogen peroxide. Further, according to the incident data base of the Research and Special Programs Administration, from 1995 through 1999, there were nine incidents involving hydrogen peroxide in air transportation.

The Safety Board concludes that given the potential for tragedy, Northwest failed to adequately alert aircraft flight crews. Several aircraft had departed before the emergency responders were able to determine what material had spilled. It is vitally important that the aircraft flight crew be notified in flight if any baggage on their airplane has been determined to have been involved in a hazardous materials spill. The flight crew should also be told how to prevent or mitigate an incident involving those materials. Therefore, the Safety Board believes that Northwest should amend its emergency response procedures and training to include notification of pilots in flight when baggage and cargo that are believed to have been involved in a hazardous materials spill have been placed on their aircraft; notifying the pilots includes clearly identifying the hazards posed by the material involved in the spill and the procedures that the pilots should take.

Further, because the danger of this type of incident is not limited to Northwest, the Safety Board has recommended that the FAA issue guidance to air carriers about the need to notify pilots in flight when baggage and cargo that are believed to have been involved in a hazardous materials spill have been placed on their aircraft; notifying the pilots includes clearly identifying the hazards posed by the material involved in the spill and the procedures that the pilots should take. The Safety Board has recommended that the FAA then require principal operations inspectors to review and amend, as necessary, air carrier manuals to ensure that air carrier procedures are consistent with this guidance.

The FAA has initiated enforcement action against the Northwest passenger for violating the Hazardous Materials Regulations.¹⁰

As a result of this investigation, the National Transportation Safety Board recommends that Northwest Airlines, Inc.:

Amend your emergency response procedures and training to include the importance of isolating baggage and other cargo that has been involved with a hazardous materials spill until it can be determined which items have been contaminated and what measures are necessary to prevent further contamination of baggage and aircraft or other hazards (such as fire or poisoning). (A-00-56)

Amend your emergency response procedures and training to include notification to pilots in flight when baggage and cargo that are believed to have been involved in a hazardous materials spill have been placed on their aircraft; notifying the pilots includes clearly identifying the hazards posed by the material involved in the spill and the procedures that the pilots should take. (A-00-57)


¹⁰ Title 49 *Code of Federal Regulations* (CFR) Subchapter "C."

Reinforce the training provided to ground operations and maintenance personnel on actions to take for a suspected fire in an aircraft cargo compartment. Also for those employees, review and modify, as appropriate, procedures and training for a suspected hazardous materials spill in an aircraft cargo compartment. (A-00-58)

The Safety Board also issued safety recommendations to the Federal Aviation Administration, the U.S. Postal Service, the Hydrogen Peroxide Safety Producers Association, and the Air Transport Association. In your response to the recommendations in this letter, please refer to Safety Recommendations A-00-56 through -58. If you need additional information, you may call (202) 314-6170.

Chairman HALL and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

By:


Jim Hall
Chairman



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: June 8, 2000

In reply refer to: A-00-59 and -60

Mr. Frank Caropreso
Regulations Affairs Manager
Hydrogen Peroxide Safety Producers Committee
C/O FMC Corporation
Box 9
Princeton, New Jersey 08543

The National Transportation Safety Board is an independent Federal agency charged by Congress with investigating transportation accidents, determining their probable cause, and making recommendations to prevent similar accidents from occurring. We are providing the following information to urge your organization to take action on the safety recommendations in this letter. The Safety Board is vitally interested in these recommendations because they are designed to prevent accidents and save lives.

These recommendations address the adequacy of emergency response guidelines, procedures, and training for responding to a hydrogen peroxide spill. The recommendations are derived from the Safety Board's investigation of the October 28, 1998, spill of hydrogen peroxide in a cargo compartment on Northwest Airlines (Northwest) flight 957 while it was en route from Orlando, Florida, to Memphis, Tennessee, and are consistent with the evidence we found and the analysis we performed. As a result of this investigation, the Safety Board has issued ten safety recommendations, two of which are addressed to the Hydrogen Peroxide Safety Producers Committee. Information supporting the recommendations is discussed below. The Safety Board would appreciate a response from you within 90 days addressing the actions you have taken or intend to take to implement our recommendations.

On the morning of October 28, 1998, 2 gallons of a 35-percent hydrogen peroxide solution in water, an oxidizer with corrosive properties, spilled in a cargo compartment of Northwest flight 957, a passenger-carrying airplane en route from Orlando to Memphis. The solution leaked from two undeclared 1-gallon plastic bottles that had split. The bottles were in an ice chest that belonged to a passenger on the flight. The leaking hydrogen peroxide contaminated three mail sacks and an undetermined number of bags.

The leak was not discovered until cargo handlers in Memphis began to unload the baggage on flight 957. Thinking that the spilled liquid was water, the cargo handlers ignored it and transferred some of the baggage to other Northwest passenger-carrying flights, including flight 7,

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which then departed for Seattle, Washington. When flight 7 arrived in Seattle, two bags in a cargo compartment were smoldering, including one that had come from flight 957.

As a result of the spill, several people required treatment. In Memphis, 11 employees were treated at the airport's first aid station because their hands had been exposed to the hydrogen peroxide, and 2 more employees went to a local clinic, where they were treated and released. In Seattle, the employee who removed the smoldering bags from the cargo compartment was exposed to fumes. He went to a hospital for treatment and was released. None of the injuries were serious. Northwest estimated that the total cost of the damage to and the downtime on the aircraft and of the damage to the baggage was more than \$40,000.

The National Transportation Safety Board determines that the probable cause of the release of undeclared hazardous material aboard Northwest Airlines flight 957 was the passenger's failure to properly package and identify the hazardous material and inadequate inquiries from the Northwest Airlines agent about the contents of the cooler offered by the passenger. Contributing to the consequences of the incident were inadequate carrier procedures for handling a hazardous materials cargo spill.

The passenger who had checked the ice chest at Orlando was a nurse. She had bought the hydrogen peroxide containers several years earlier and stored them unopened at an assisted care facility for the elderly in Fort Pierce, Florida, that she had once owned. Before her trip on flight 957, she had packed the two plastic bottles of hydrogen peroxide in a plastic ice chest with some sand and a bag of rolls.

She arrived at the airport at 0600 eastern standard time (EST); the flight was scheduled to depart at 0630 EST. She attempted to check seven items, including the ice chest, at Northwest's roadside skycap service. According to the skycap, he had been reluctant to check the bags because Northwest allows a passenger to have only two items checked without paying additional fees. He had told her that the fees must be paid at the ticket counter inside the terminal, but she explained that she was late and persuaded him to check all seven of her items. She tipped him \$20 dollars and rushed off.¹

The skycap said that he had asked the woman whether the ice chest contained dry ice, a hazardous material with special limitations in air transportation.² She did not declare that there were any hazardous materials in her baggage³ and later told investigators that she was not aware that hydrogen peroxide was a hazardous material. She checked in with Northwest at the gate and left Orlando on flight 957. There were no reports of incidents or injuries at the Orlando airport involving her baggage.

¹ Northwest management indicated that the skycap was a Northwest employee and was authorized to collect the fees for extra baggage. Northwest took disciplinary action against the skycap.

² Northwest hazardous materials training specifically addresses questioning passengers about hazardous materials in ice chests.

³ A search of her other baggage in Seattle revealed other undeclared hazardous materials, including small arms ammunition, an aerosol can of lubricant (a flammable gas), and a tube of gun oil (a combustible liquid).

After flight 957 arrived in Memphis, two Northwest ramp employees entered the cargo compartments, between 0730 and 0745 central standard time, and began transferring the baggage to other aircraft in the morning bank of flights.⁴ Both employees noted wet baggage and a clear liquid on the floor. They assumed the liquid was water that had leaked from the ice chest or from a shipment of tropical fish.⁵

About 10 minutes after the baggage was unloaded, the employees who had handled the wet baggage and mail sacks began to complain that their hands were tingling and turning white. By then, some of the baggage had been transferred to other airplanes, and some had been returned to passengers. The ice chest and several bags had been loaded onto flight 7.

Because employees were complaining about their hands, Northwest contacted the airport's fire station, and it responded to the site. Northwest also contacted the airport's post office, which sent a postal employee to pick up the wet mail sacks. A ramp employee retrieved the ice chest from flight 7. When he was told that the ice chest probably contained a hazardous material, he left to seek medical attention. After he left, the pilot of flight 7 noticed that there was a cluster of emergency responders and Northwest employees near the airplane. The pilot asked them about the nature of the emergency. They told him that the ice chest might contain a hazardous material. The pilot asked whether the ice chest had been on flight 7. Not knowing that the chest had been on flight 7, several Northwest employees told the pilot that it had not. Thinking that his airplane was not affected by the incident, the pilot of flight 7 departed as scheduled.

The emergency responders did an on-site examination and found that each bottle had split open and that the hydrogen peroxide had leaked from the bottles and the ice chest. Each bottle had a label that said "Vero Chemical Distributors, Inc.," and had generic warnings about flammable materials. The words "Hydrogen Peroxide" were handwritten in an upper corner of each label. When the responders questioned the passenger who had checked the ice chest, she told them that the bottles had contained a 35-percent solution of hydrogen peroxide.

During the emergency, the fire station responders used the *North American Emergency Response Guide* and a material safety data sheet about hydrogen peroxide as references. Northwest stated that it also contacted the Minnesota Poison Control Center.⁶ (While there is no record of the information provided by the center, a previous employee indicated that, given the nature of the center, its information would have focused on the medical hazards, including the fact that hydrogen peroxide can damage skin.) The information gathered described some of the hazards posed by hydrogen peroxide, but much of it did not point out that hydrogen peroxide that has dried on certain materials is a fire hazard. A fire station responder stated that the responders were concerned about the danger of fire from materials exposed to the oxidizing properties of hydrogen peroxide and had warned the Northwest employees.

⁴ Memphis is one of Northwest's hub airports. Northwest has 3 daily banks of about 40 flights; the planes are at the airport for only 1 to 2 hours.

⁵ According to the ramp employees, it is common to discover ice chests leaking due to melting ice. Also, live fish are shipped in plastic bags inside fiberboard boxes, and the bags occasionally break, spilling the water from the box.

⁶ At the time of the incident, the Minnesota Poison Control Center was under contract to Northwest to provide hazardous materials information.

Hydrogen peroxide is a very powerful oxidizing agent that can oxidize all organic compounds and a wide range of inorganic ones. It is not flammable, but it can readily cause other materials to burn. Natural materials like wood, paper, cotton, and leather are very susceptible to fire when exposed to hydrogen peroxide. These reactions are enhanced when the material contains dirt, especially metallic compounds of copper, silver, or mild steel.⁷ If a hydrogen peroxide solution is allowed to evaporate, the water evaporates more quickly than the hydrogen peroxide does, causing the solution to become more concentrated. As a hydrogen peroxide solution becomes more concentrated and is exposed to organic materials and dirt or metallic compounds, the hydrogen peroxide begins to decompose. This decomposition results in an exothermic reaction⁸ and the release of oxygen, which will support combustion.

In the time between the discovery of the spill and the identification of the hazardous material, an undetermined number of bags potentially contaminated with hydrogen peroxide were transferred to 13 other Northwest aircraft for flights that departed Memphis, including flight 7 to Seattle. Northwest began making calls to Northwest management at all of the destination airports, initially focussing on airports receiving flights that had baggage transferred from flight 957. Callers provided information that focussed on the injuries to the Memphis ground crew, first aid, and the need to use protective gloves when handling the baggage, and not on the fire hazard. It was recommended that people unloading the airplane check for wet baggage and, if it was discovered, condemn and replace it. A call was also made to Northwest's Systems Operations Control, which telexed information on the spill and a warning about potentially contaminated baggage to all Northwest operations offices, station managers, maintenance managers, and control centers. No similar warnings were sent to the pilots of the aircraft containing potentially contaminated baggage.

Before flight 7 landed in Seattle, the Northwest employees there knew that the airplane might be carrying contaminated baggage, and the baggage handlers, as Memphis had suggested, were protecting their hands with rubber gloves. However, no one in Seattle had independently researched the hazards posed by hydrogen peroxide, and the Northwest telephone call from Memphis had not mentioned fire hazards. Consequently, no one in Seattle was prepared for the possibility of a fire. The Northwest employees in Seattle had told the local emergency responders about the Memphis spill but had not asked any responders to stand by when flight 7 arrived in case there was a fire.

The baggage handlers reported that when they opened the cargo compartments of flight 7, they found smoke, but no flames, coming from the area of two adjacent suitcases. One handler said the smoke was "like someone blowing on a good cigar." The handlers backed away, and an equipment service employee without any protective equipment climbed into the compartment and retrieved the smoldering suitcases. Northwest called the fire department, which drowned the suitcases with water. A short time later, the equipment service employee became nauseated and was taken to a local hospital, where he was treated and released.

⁷ Mild steel is a carbon steel with a maximum of about 0.25 percent carbon.

⁸ A chemical reaction that results in the generation and release of heat.

The 1996 *North American Emergency Response Guidebook* refers the reader to Guide 140, "Oxidizers," when dealing with a hydrogen peroxide aqueous solution with not less than 20 percent but not more than 60 percent hydrogen peroxide. Guide 140 is about oxidizers in general, not about hydrogen peroxide specifically. The guide does not warn of the fire hazard caused by hydrogen peroxide drying on materials; however, not all oxidizers are shipped in solution with water, nor do they necessarily concentrate and become more reactive when they dry. As the guidebook states:

It is primarily a guide to aid first responders in quickly identifying the specific or generic hazards of the materials(s) involved in the incident, and protecting themselves and the general public during the initial response phase of the incident....It is not intended to provide information on the physical or chemical properties of dangerous goods.

The Memphis fire department obtained specific information on hydrogen peroxide from an unidentified material data safety sheet for the material. Several material safety data sheets for hydrogen peroxide, including those provided by Northwest, were reviewed by investigators. Only about half the sheets reviewed warned that the product drying on clothing or combustible materials may cause a fire. The Safety Board concludes that, given the use of material safety data sheets by emergency responders and the potential for fire caused by hydrogen peroxide drying on certain materials, all material safety data sheets about hydrogen peroxide should include a warning about the danger. Therefore, the Safety Board believes that the North American Hydrogen Peroxide Safety Producers Committee should urge its members to revise their material data safety sheets about hydrogen peroxide to include warnings about the dangers of allowing hydrogen peroxide to dry on organic materials (including paper, fabric, cotton, and leather), which may result in a fire.

The initial reaction of the baggage handlers to the clear water-like liquid in the cargo compartment of flight 957 was not unreasonable, given Northwest's indication that there are frequent spills of water from ice chests and tropical fish shipments. However, the Safety Board concludes that hydrogen peroxide presents a serious hazard to air transportation because it can be mistaken for water and can cause a fire if it is allowed to dry on cargo or baggage. Therefore, the Safety Board has recommended that the Federal Aviation Administration (FAA) develop and distribute to carriers guidance about the difficulty of identifying a hydrogen peroxide spill and about the danger of allowing hydrogen peroxide to dry on organic materials (including paper, fabric, cotton, and leather), which may result in a fire.

Given the unique knowledge of hydrogen peroxide that the North American Hydrogen Peroxide Safety Producers Committee has, the Safety Board believes that the committee should assist the FAA in developing guidance for air carriers about the difficulty of identifying a hydrogen peroxide spill and about its hazards. The guidance should explain, at a minimum, that hydrogen peroxide is colorless, has little odor, and may be mistaken for water; the guidance should also warn of the danger of allowing hydrogen peroxide to dry on organic materials (including paper, fabric, cotton, and leather), which may result in a fire.

The FAA has initiated enforcement action against the Northwest passenger for violations of the Hazardous Materials Regulations.⁹

As a result of this investigation, the National Transportation Safety Board recommends that the Hydrogen Peroxide Safety Producers Committee:


Urge your members to revise their material data safety sheets for hydrogen peroxide to include warnings about the dangers of allowing hydrogen peroxide to dry on organic materials (including paper, fabric, cotton, and leather), which may result in a fire. (A-00-59)

Assist the Federal Aviation Administration in developing guidance for air carriers about the difficulty of identifying a hydrogen peroxide spill and about its hazards. Include, at a minimum, the fact that hydrogen peroxide is colorless, has little odor, and may be mistaken for water; the guidance should also warn of the danger of allowing hydrogen peroxide to dry on organic materials (including paper, fabric, cotton, and leather), which may result in a fire. (A-00-60)

The Safety Board also issued safety recommendations to the Federal Aviation Administration, the U.S. Postal Service, Northwest Airlines, Inc., and the Air Transport Association. In your response to the recommendations in this letter, please refer to Safety Recommendations A-00-59 and -60. If you need additional information, you may call (202) 314-6170.

Chairman HALL and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

By:


Jim Hall
Chairman

⁹ Title 49 *Code of Federal Regulations* (CFR) Subchapter "C."



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: June 28, 2000

In reply refer to: A-00-61 and -62

Honorable Jane F. Garvey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On October 7, 1998, at 0710 eastern daylight time, a Continental Airlines (Continental) Boeing 727-224 airplane, N66734, operating as flight 1521, experienced an uncontained failure of its No. 2 (center), Pratt & Whitney (P&W) JT8D-9A engine during the takeoff roll at Miami International Airport, Florida. Flight 1521 was a regularly scheduled domestic passenger flight from Miami to Houston, Texas, operating under the provisions of 14 Code of Federal Regulations Part 121. The captain reported that while he was advancing the engine power levers, he heard a loud bang and immediately retarded the power levers, rejecting the takeoff. After the airplane was stopped, the flight crew discharged one fire bottle, and all crewmembers and passengers deplaned using a portable airstair. There were no reported injuries.

The National Transportation Safety Board's investigation revealed that fragments of the engine's 8th-stage high pressure compressor (HPC) hub penetrated the engine, passed through the cowlings, and penetrated the airplane's vertical stabilizer. Investigators determined that the trajectory of the liberated hub fragments had come within inches of the rudder control cables. Pieces of the engine and cowling were recovered from the runway and surrounding areas.

Continental maintenance records indicated that the 8th-stage hub, part number 787008, serial number N33354, had accumulated 176 cycles since its last overhaul and 15,539 total cycles at the time of the accident; the hub has a published life limit of 20,000 cycles. The maintenance records indicated that, during its last overhaul, the 8th-stage hub had been nickel-cadmium (NiCd) plated¹ by Wings Aviation Services, Inc. (Wings), Miami, Florida, in April 1996 before installation into the accident engine by Greenwich Air Services, Miami (now GE Engine Services) in February

¹ Steel rotating engine parts, such as hubs and disks, undergo a NiCd plating process at manufacture and overhaul to protect them from corrosion and pitting.

1998. According to the P&W JT8D Engine Manual and the Overhaul Standard Practices Manual, the NiCd plating process is accomplished by applying a 0.0004- to 0.0007-inch layer of nickel on the base material (steel), followed by a 0.0001- to 0.0002-inch layer of cadmium on top of the nickel. The P&W JT8D Engine Manual indicates that the nickel thickness should be measured using an approved coating thickness gage before the process is continued. The process then calls for the hub to be baked² for 60 minutes at about 630° F.

Metallurgical examination of the 8th-stage hub at the Safety Board's materials laboratory revealed that the primary hub fracture stemmed from a crack that extended inboard from the rim radius partially into the bore. The fracture initiation site contained a significant amount of cadmium in contact with the base material and on the fracture surface, indicating that the hub failed because of cadmium embrittlement.³ The source of the cadmium was the NiCd plating on the exterior surface of the hub. Analysis of the plating on multiple cross sections through the hub revealed primarily a single layer of diffused NiCd ranging from 0.00008 to 0.00019 inches thick and no pure nickel layer adjacent to the steel surface. The exact thickness of the initial nickel layer that was applied to the accident hub could not be determined because the diffusion process reduces it to create the NiCd layer. However, it became clear during the investigation that insufficient nickel was applied to the hub during the plating process because all measurements of the diffused NiCd layer were less than the 0.0004- to 0.0007-inch specification for the initial pure nickel layer. This deficiency suggests that the nickel thickness inspection specified in the maintenance manual was either omitted or performed incorrectly.

During its investigation of this accident, the Safety Board learned that on October 12, 1995, customer audit of Wings revealed that the facility had not been measuring the nickel thickness as required but was performing only a visual inspection. In addition, during a November 24, 1998, visit at the Wings facility, Safety Board staff witnessed an electrical malfunction of a nickel plating tank while a disk was being NiCd plated. This malfunction caused a circuit breaker to trip, which terminated the plating process before sufficient nickel was applied. No audible or visual alarms alerted the operator that the tank had malfunctioned and shut down before the process had been completed.

An uncontained engine failure similar to the Continental failure occurred on April 28, 1997, and also involved an improperly NiCd plated part. United Airlines (United) flight 1210, a Boeing 737-222 equipped with P&W JT8D-7B engines, experienced an uncontained failure of the No. 2 (right) engine's 10th-stage HPC disk during takeoff from O'Hare International Airport, Chicago, Illinois. The captain rejected the takeoff following the engine failure, stopped the airplane, discharged one fire bottle, and ordered an evacuation of the airplane. There was no secondary airframe damage, and two passengers sustained minor injuries during the evacuation.

² The baking process causes the cadmium to diffuse into the nickel. Thus, when the prescribed thickness of nickel and cadmium has been applied, baking creates two distinct layers—a pure nickel layer next to the surface of the hub and a diffused NiCd layer on top of the nickel layer. The nickel acts as a barrier coating between the cadmium and the base material to prevent the cadmium from migrating into the steel.

³ Cadmium embrittlement is a brittle cracking phenomenon in a normally ductile material that is caused by diffusion of cadmium into the material when it is subsequently stressed in tension. When a sufficient cross section of the part is cracked, the part separates under normal applied loads.

Metallurgical examination of the United 10th-stage disk revealed fractures that stemmed from large intergranular areas in the steel surface where solidified molten cadmium was present; no pure nickel layer was observed adjacent to the steel. The Safety Board determined that the 10th-stage disk failed because of cadmium embrittlement as a result of an inadequate nickel coating. Investigation of United's NiCd plating process revealed that United used deposition rates for determining plating thickness instead of using gages to measure each part as specified in the engine manual. The Safety Board's findings prompted Safety Recommendation A-97-83, which asked the FAA to review and revise, in conjunction with engine manufacturers, air carriers, and certificated repair stations, the published plating guidance, plating equipment, inspection procedures, inspector training, including any electronic and visual aids, and supervision currently in place for performing NiCd plate, and other plating processes that could lead to cadmium embrittlement of steel rotating engine parts.

The FAA responded to the recommendation by evaluating NiCd plating practices, procedures, equipment, training, and inspection standards at two repair stations. The review revealed that improper processing during maintenance and overhaul was the root cause of failure of steel rotating parts. The FAA also issued Flight Standards Information Bulletin for Airworthiness (FSAW) 98-11, which provides information to all FAA inspectors involved in the certification and surveillance of repair stations and operators authorized to perform NiCd plating operations. FSAW 98-11 directs maintenance inspectors to perform repair station audits during normal surveillance to ensure that proper plating procedures are being followed and to provide background information on cadmium embrittlement, recent failures in service, and repair station audit findings. On March 12, 1999, on the basis of the FAA's response, the Safety Board classified Safety Recommendation A-97-83 "Closed—Acceptable Alternate Action." Although FSAW 98-11 appears to provide inspectors who are visiting overhaul shops with adequate information to detect deficiencies in the NiCd plating process, it does not appear to be sufficient in preventing engine parts from being improperly plated during routine operations when an inspector is not present or if the process is momentarily left unattended.

Although the Continental and United uncontained HPC failures did not cause a loss of life or catastrophic airplane damage,⁴ the Safety Board notes that the failure of steel rotating engine parts, such as an HPC disk or hub, can have more critical consequences, especially if it occurs at maximum power or if fragments penetrate fuel lines, fuel cells, critical control system components, or hydraulic systems. For instance, on May 3, 1991, during the takeoff roll, a Ryan International Airlines Boeing 727-100QC, departing from Windsor Locks, Connecticut, experienced a P&W JT8D HPC disk failure (burst) that resulted from a fatigue crack. Engine debris was ejected and severed an engine fuel supply line. The fuel ignited, burned through the fuselage, and ignited the cargo. The flight crew aborted the takeoff but was unable to extinguish the fire before it destroyed the entire airplane.⁵ In addition, on June 8, 1995, also during the takeoff roll, a ValuJet Douglas DC-9-32, departing from Atlanta, Georgia, experienced a P&W

⁴ As noted previously, in the Continental accident, liberated hub fragments came within inches of the rudder control cables. If those cables had been severed, the consequences of that incident could have been much more severe.

⁵ For more information, see Brief of Accident NYC91FA125.

JT8D HPC disk burst that resulted from a fatigue crack. As a result, shrapnel penetrated the fuselage and punctured an engine fuel supply line, causing a cabin fire that destroyed the airplane. A flight attendant sustained serious injury when she was struck by hot engine debris, and another flight attendant and five passengers received minor injuries.⁶

The Continental and United events demonstrate that failure to properly perform all steps of the NiCd plating procedure on steel rotating engine parts can lead to catastrophic failure of the parts. After reviewing the circumstances of these events and considering Safety Board staff's observations at Wings, the Board is concerned about the continued NiCd plating of steel rotating engine parts. The Board is aware that there are FAA-approved corrosion protection coating alternatives to NiCd plating that have been used successfully for many years to resist oxidation and corrosion in commercial and military gas turbine engines. These coatings are aluminum-based paints that do not diffuse into and embrittle steel like cadmium; therefore, no protective layer is needed between these coatings and the steel. The Safety Board is not aware of any failures of steel parts related specifically to problems with aluminum-based paints.

The Safety Board is also aware that before the April 1997 incident, United solicited and gained approval from P&W to use Sermetel (one of the approved aluminum-based paints) instead of NiCd plating on P&W steel HPC disks.⁷ United informed the Safety Board that it had voluntarily discontinued NiCd plating of HPC disks because United believed Sermetel has better corrosion and erosion protection. The Board considers the use of such alternative corrosion protection methods important in the effort to prevent failures of steel rotating parts in turbine engines. Therefore, the Board believes that the FAA should require the use of alternative corrosion protection methods instead of NiCd plating on steel rotating engine parts to eliminate the hazards introduced by improper NiCd plating.

Further, the events discussed in this letter suggest that such improper NiCd plating techniques may continue to be performed in industry and that maintenance personnel may not be receiving adequate initial and recurrent training in the NiCd plating process. Therefore, the Board believes that the FAA should issue a flight standards information bulletin requiring principal maintenance inspectors to ensure that facilities performing plating operations have a specific training program for the NiCd plating process and that maintenance personnel receive this training on a recurring basis.

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

Require the use of alternative corrosion protection methods instead of nickel-cadmium (NiCd) plating on steel rotating engine parts to eliminate the hazards introduced by improper NiCd plating. (A-00-61)

⁶ National Transportation Safety Board. 1996. *Uncontained Engine Failure/Fire ValuJet Airlines Flight 597 Douglas DC-9-32, N908VJ, Atlanta, Georgia, June 8, 1995*. Aircraft Accident Report NTSB/AAR-96/03. Washington, D.C.

⁷ United began sending disks through the Sermetel process in March 1997.

Issue a flight standards information bulletin requiring principal maintenance inspectors to ensure that facilities performing plating operations have a specific training program for the nickel-cadmium plating process and that maintenance personnel receive this training on a recurring basis. (A-00-62)

Chairman HALL and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

By: 
Jim Hall
Chairman